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ABSTRACT

This combination workbook and testbook on mathematics is one in a series of 20 individually bound units of instruction for carpentry apprenticeship classes. Three diagnostic tests and suggestions for their administration are included to identify areas in which the apprentice may need work and study. The 12 topics covered are whole numbers; fractions; decimals; percents; conversion of units; compound numbers; decimal and fractional equivalents; perimeters, areas, and volumes; squares and square roots; the right triangle; lumber products and board measure; and metric measurements and conversion. For each topic these materials are provided: questions to direct study of the content, text, and a study guide. Required and recommended instructional materials are listed. The final section of this volume contains an objective test for each of the 12 topics of the workbook. (YLB)

Course in Carpentry

MATHEMATICS

Workbook and Tests

Prepared under the direction of the

Carpenters' Statewide Joint Apprenticeship and Training Committee
Carpentry Curriculum Revision Committee

and the

Bureau of Publications, California State Department of Education

A column labeled "Date Assigned" has been provided at the right-hand side of each page of the workbook section in the contents. Whenever your instructor assigns a topic, the date should be written in the appropriate blank. When you have completed the topic satisfactorily, your instructor should place his or her initials next to the assignment date. If this procedure has been followed, and you should transfer from one school to another, you will have an accurate record of the work you have completed. This procedure is intended to ensure that you complete each topic and to ensure that you do not have to duplicate work on topics already studied.

To provide other school records needed, be sure to fill in the blanks below, giving your name, home address, and telephone number. Then ask your instructor to fill in the official date of your enrollment in his or her class and to sign where indicated.

NAME ______________________________

ADDRESS ______________________________

______________________ PHONE ______________

DATE ENROLLED ______________________________

INSTRUCTOR(S) ______________________________

____

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721 Capitol Mall
Sacramento, CA 95814
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Foreword

In today's society competence in basic mathematics is essential. Almost every job requires mathematical skills, and the work of the carpenter is no exception. In fact, the nature of your work as an apprentice, and later as a journey-level carpenter, will require you to use such skills to a greater degree than workers in many other professions.

As a carpenter you will have to make accurate computations and measurements of many kinds. You will have to be able to perform the basic operations of addition, subtraction, multiplication, and division with whole numbers, common fractions, decimal fractions, percents, and the like. You will have to be able to recognize various shapes and figures, and you will have to know how to determine such measures as the areas and perimeters of these shapes and figures. Computational and measurement skills are "tools of the trade" in such tasks as estimating labor costs, determining worker benefits, and ordering and installing materials. I urge you, therefore, to study or review the material in this book carefully, and to save the book for future reference, because the worker who possesses the skills to solve mathematical problems, or who knows where to look for information on how to solve them, is an asset to employers and a credit to the industry.

In carpentry you have chosen a challenging and rewarding career. The many hours of on-the-job training and the additional hours of related instruction that you must complete may sometimes seem overwhelming during your training. But once you have completed that training, you will be a full-fledged member of one of the most vital and honored professions in the world, and you will have, even in poor economic times, a freedom of job movement unequaled in most industries.

I am pleased that the Department of Education, in cooperation with labor and management, is able to provide you with up-to-date information needed in your training. On behalf of the Department, I wish you great success in your career as a carpenter.

Bill Honig

Superintendent of Public Instruction

Preface

The California State Department of Education, through the Bureau of Publications, provides for the development of instructional materials for apprentices under provisions of the California Apprentice Labor Standards Act. These materials are developed through the cooperative efforts of the Department of Education and employer-employee groups representing apprenticeable trades.

Mathematics, which was first published in 1975, was planned and prepared under the direction of the Carpenters' Statewide Joint Apprenticeship and Training Committee and the Carpentry Curriculum Revision Committee. Many individuals representing employers, employees, and public education contributed to the 1975 publication. Those representing central and northern California included James Brooks, Charles Hanna, Gordon Littman, Charles Royalty, Hans Wachsmuth, Bill Walker, and Jimps Wilcox. Those representing the Los Angeles area included Tom Benson, Creighton Blenkhorn, John Cox, Allen Kocher, and Al Preheim. San Diego representatives were Paul Cecil, Jess Dawson, Robert Moorhouse, and Billy Williams. Bob Klingensmith, Publications Consultant, Apprenticeship, directed the work on this 1983 edition for the Bureau of Publications.

This publication is one of a series of individually bound units of instruction for carpentry apprenticeship classes. It consists of two parts—a workbook section and a tests section. A test is provided for each topic in the workbook section, and each test sheet is perforated and arranged so that it can be easily removed from the book at the discretion of the instructor without disturbing any other test. These books reflect the continuing cooperative effort of labor, management, local schools, and the Department of Education to provide the best instructional materials for California apprenticeship classes. They are dedicated to excellence in the training of carpenter apprentices.

GILBERT R MARGUTH, JR
Deputy Superintendent for Administration

THEODORE R SMITH
Editor in Chief
Bureau of Publications

Diagnostic Tests

The diagnostic tests included on the following pages are intended primarily to identify areas of mathematics in which the apprentice may need work and study. The following procedure is suggested for use in administering the diagnostic tests and assigning topics for study:

1. The instructor will assign Diagnostic Test No. 1 and correct the apprentice's test. If the apprentice is able to complete the test satisfactorily, the instructor will assign him or her to take Diagnostic Test No. 2. If the apprentice is *not* able to complete the test satisfactorily, the instructor will ask the apprentice to study the workbook topics that include the types of material with which he or she had difficulty on the test.
2. After studying the assigned workbook topics and completing the study guide problems for each topic assigned, the apprentice will rework those problems answered incorrectly on Diagnostic Test No. 1. The instructor will check the problems to determine whether the apprentice is prepared to take Diagnostic Test No. 2. If necessary, the instructor will assign further review work.
3. Once the apprentice has demonstrated the ability to complete satisfactorily the work in Diagnostic Test No. 1, the instructor will assign her or him to take Diagnostic Test No. 2. The procedures outlined above will be followed again. When the apprentice has satisfactorily completed Diagnostic Test No. 2, the instructor will have the apprentice take Diagnostic Test No. 3. Again, the instructor will assign review work if needed.
4. If the work of the apprentice on the diagnostic tests indicates a reading problem rather than a lack of knowledge of mathematics, the apprentice should be referred to an appropriate source of help in the area of reading.
5. Satisfactory completion of the three diagnostic tests is to be interpreted as an indication that the apprentice needs no further work in mathematics at this point. If the apprentice should demonstrate a need, however, for practice in areas of mathematics not included in the workbook topics, the instructor may assign additional problems from a designated source.

The diagnostic tests are designed to cover the full range of mathematical skills that a carpenter must have, and they are arranged in order of difficulty: Diagnostic Test No. 1 is the easiest of the three tests, and Diagnostic Test No. 3 is the most difficult.

Mathematics

DIAGNOSTIC TEST NO. 1

Write the answer to each problem in the blank provided at the right.

Topic 1—Whole Numbers

1. Add 364, 24, 862, 592, 17, and 206. 1._______
2. Subtract 12,765 from 23,734. 2._______
3. Multiply 3,692 by 97. 3._______
4. Divide 34,671 by 137. 4._______

Topic 2—Fractions

1. Add $14\frac{3}{8}$, $1\frac{3}{16}$, $43\frac{1}{2}$, and $2\frac{1}{4}$. 1._______
2. Subtract $3\frac{1}{8}$ from $7\frac{1}{2}$. 2._______
3. Multiply $\frac{1}{2}$ by $\frac{3}{8}$ 3._______
4. Divide $\frac{1}{2}$ by $\frac{3}{8}$. 4._______

Topic 3—Decimals

1. Add 4.0, 6.2, 0.37, and 3.702. 1._______
2. Subtract 0.17 from 3.6. 2._______
3. Multiply 0.05 by 3.23. 3._______
4. Divide 12 by 0.24. 4._______

Topic 4—Percent

1. Compute 21 percent of 83. 1._______
2. Find what percent 6 is of 24. 2._______
3. Express $21\frac{1}{4}$ percent as a decimal. 3._______
4. Express 0.015 as a percent. 4._______

Topic 5—Conversion of Units

1. Convert 8 inches to the decimal part of a foot. 1. ______
2. Convert 14 feet 7 inches to inches. 2. ______
3. Convert 351 cubic feet to cubic yards. 3. ______
4. Convert 564 inches to feet. 4. ______

Topic 6—Compound Numbers

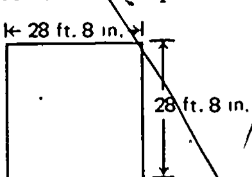
1. Add 17 feet 8 inches, 23 feet 3 inches, and 9 feet 5 inches. 1. ______
2. Subtract 27 feet 10 inches from 45 feet 3 inches. 2. ______
3. Multiply 13 feet 6 inches by 7. 3. ______
4. Divide 24 feet 8 inches by 4. 4. ______

Topic 7—Decimal and Fractional Equivalents

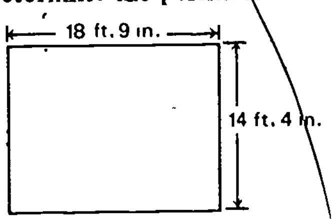
1. Express 23 percent as a decimal. 1. ______
2. Express 0.12 as a percent. 2. ______
3. Express 0.125 as a percent. 3. ______
4. Express 75 percent as a common fraction. 4. ______

Topic 8—Perimeters, Areas, and Volumes

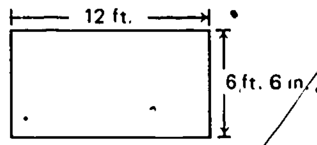
1. Determine the perimeter of the figure shown below. 1. ______



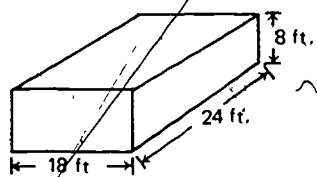
2. Determine the perimeter of the figure shown below. 2. ______



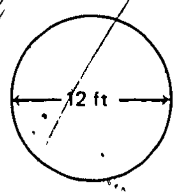
3. Determine the area of the figure shown below. 3. ______



4. Determine the volume of the figure shown below. 4. ______



5. Determine the area of the figure shown below. 5. ______



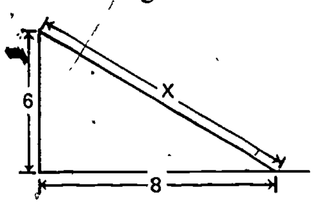
Topic 9–Squares and Square Root

1. Find the square of 27. 1. ______

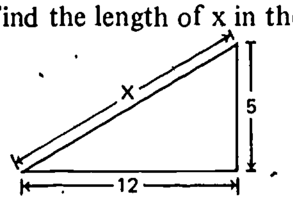
2. Find the square root of 625. 2. ______

Topic 10–The Right Triangle

1. Find the length of x in the triangle shown below. 1. ______



2. Find the length of x in the triangle shown below. 2. ______



3. Determine the number of degrees in the remaining interior angle of a right triangle if the other interior angle is 35 degrees. 3. ______

4. State the sum of all interior angles of any triangle. 4. ______

Topic 11—Lumber Products and Board Measure

1. Determine the number of board feet in 26 pieces of lumber 2 inches by 4 inches by 24 feet. 1. ________

Topic 12—Metric Measurements and Conversion

1. Convert 10 metres to decimetres. 1. ________

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MATHEMATICS

DIAGNOSTIC TEST NO. 2

Write the answer to each problem in the blank provided at the right.

Topic 1—Whole Numbers

1. Add 3,642; 579; 62,850; 47; and 7,762. 1.________
2. Subtract 268 from 4,130. 2.________
3. Multiply 8,090 by 739. 3.________
4. Divide 7,436 by 26. 4.________

Topic 2—Fractions

1. Add $^{13}/_{16}$, $5\,^{7}/_{8}$, $21\,^{5}/_{8}$, and $^{3}/_{4}$. 1.________
2. Subtract $95\,^{3}/_{4}$ from $152\,^{5}/_{16}$. 2.________
3. Multiply $1\,^{1}/_{4}$ by $1\,^{1}/_{4}$. 3.________
4. Divide $3\,^{3}/_{8}$ by $1\,^{1}/_{2}$. 4.________

Topic 3—Decimals

1. Add 964.07, 0.007, 8.3, and 32. 1.________
2. Subtract 78.02 from 732.002. 2.________
3. Multiply 107.42 by .060. 3.________
4. Divide 1120.15 by 21.5. 4.________

Topic 4—Percent

1. Determine the selling price of an item that retails for $25.75 if a 12 percent discount is allowed. 1.________
2. Determine the selling price of an article that cost a dealer $12.50 and was marked up 18 percent above the cost. 2.________

Topic 5—Conversion of Units

1. Convert 0.8125 to 16ths. 1.________
2. Convert 931.41 feet to feet and inches (to the nearest 8th). 2.________

Topic 6—Compound Numbers

1. Add 4 yards 2 feet 8 inches, 3 feet 11 inches, and 6 yards 6 feet 6 inches. 1.________

2. Subtract 16 degrees 16 minutes from 34 degrees 8 minutes. 2.________

3. Multiply 24 feet 6 inches by 13 feet 9 inches. 3.________

4. Divide 42 feet 5 ¼ inches by 7. 4.________

Topic 7—Decimal and Fractional Equivalents

1. Convert 0.95 inch to a fractional part of an inch (to the nearest 16th). 1.________

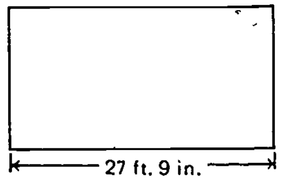
2. Convert 0.95 foot to inches (to the nearest 8th). 2.________

3. Convert 0.0125 to a percent. 3.________

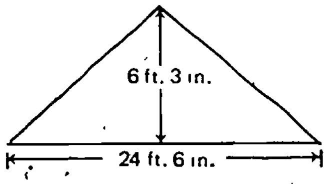
4. Convert 9 ⅜ inches to a decimal part of a foot. 4.________

Topic 8—Perimeters, Areas, and Volumes

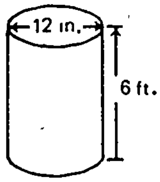
1. Find the perimeter of the figure shown below if the length is twice the width. 1.________



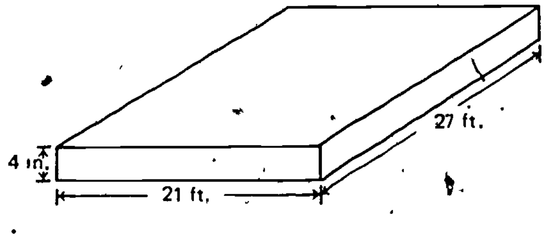
2. Determine the area of the figure shown below (to the nearest one-half square foot). 2.________



3. Determine the volume of the figure shown below (to the nearest cubic foot). 3.________



4. Calculate the volume of the figure shown below (in cubic yards). 4.________



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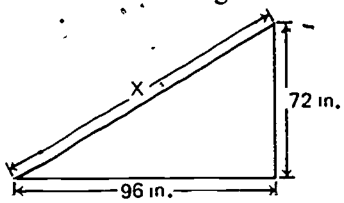
Topic 9–Squares and Square Root

1. Find the square of 142. 1. ______

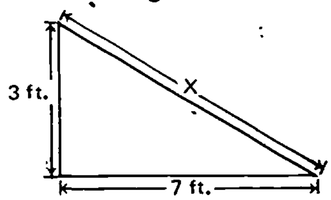
2. Find the square root of 729. 2. ______

Topic 10–The Right Triangle

1. Determine the length of X in inches in the triangle shown below. 1. ______



2. Determine the length of X in feet in the triangle shown below. 2. ______



Topic 11–Lumber Products and Board Measure

1. Determine the number of board feet in 102 pieces of lumber 4 inches by 8 inches by 12 feet. 1. ______

Topic 12–Metric Measurements and Conversion

1. Convert 2,500 millimetres to metres. 1. ______

MATHEMATICS

DIAGNOSTIC TEST NO. 3

Write the answer to each problem in the blank provided at the right.

Topic 1—Whole Numbers

1. Add 637, 62, and 979, and round off the answer to the nearest hundred. 1.______

2. Subtract 978,295 from 6,327,000. 2.______

3. Determine the product of 24, 18, and 69. 3.______

4. Determine the quotient as a whole number and a common fraction if the dividend is 989 and the divisor is 29. 4.______

Topic 2—Fractions

1. An exterior wall has a $\frac{7}{8}$-inch coat of stucco and $3\frac{1}{2}$-inch studs; the interior wall has $\frac{1}{2}$-inch sheetrock covered with $\frac{1}{4}$-inch prefinished plywood panels. Determine what width jamb (a wood member that frames a door opening) should be ordered for the exterior door frames. 1.______

2. The bottom of the ceiling joists is 8 feet 1 inch above the top of the subfloor; the bottom plate and double upper plate are made of $1\frac{1}{2}$-inch-thick material. Determine the common stud length in inches. 2.______

3. Determine the number of studs remaining from an original order of 312 if $\frac{3}{4}$ of the order has been used. 3.______

4. Determine how many $1\frac{1}{2}$-inch strips can be ripped from a $6\frac{3}{8}$-inch-wide board if each saw kerf (the width of the cut made by the blade of the saw) is $\frac{1}{8}$ inch wide. 4.______

Topic 3—Decimals

1. On Monday a contractor had \$5,783.29 in his bank account. On Tuesday he wrote checks of \$236.64, \$183.92, \$242.63, \$23.14, and \$369.28. Determine his new balance after these checks are deducted. 1.______

2. A contractor's bid for an alteration job was \$2,629.50, and his costs were as follows: labor, \$1,322.18; materials, \$987.89; and miscellaneous, \$76.43. Determine his profit. 2.______

3. Galvanized machine bolts $\frac{1}{2}$ inch x 4 inches cost \$1.33 per dozen. Determine the cost of 54 bolts. 3.______

4. Determine the cost per square foot of a 1,875-square-foot house costing \$27,187.50. 4.______

Topic 4—Percent

1. A contractor's profit was $450, and the profit was 12 percent of the bid. Determine the amount of the contract. (Consider profit as part of the cost.) 1. ________

2. Determine the tongue-and-groove flooring needed to lay a floor of 1,386 square feet if the waste allowance (the amount that must be added to allow for milling and cutting waste) is 33 $\frac{1}{3}$ percent. 2. ________

Topic 5—Conversion of Units

1. Determine the number of square yards of linoleum needed to cover a laundry room floor having an area of 150 square feet. (Disregard waste allowance.) 1. ________

2. Determine the number of acres contained in a plot of 98,010 square feet. (An acre of land contains 43,560 sq. ft.) 2. ________

Topic 6—Compound Numbers

1. In a stairway, the bottom plate is 1$\frac{1}{2}$ inches thick, the upper floor joists 10$\frac{3}{4}$ inches wide, the subfloor $\frac{5}{8}$ inch thick, the upper finish floor $\frac{25}{32}$ inch thick, the stud length 7 feet 8$\frac{1}{4}$ inches, and the two top plates each 1$\frac{1}{2}$ inches thick. Determine the total height of the stairway in inches. 1. ________

2. The first floor elevation is 85.50 feet. Determine the elevation of the basement floor in feet and hundredths if the basement floor is 8 feet 9 inches lower than the first floor. 2. ________

3. Determine the number of cubic yards of concrete needed to pour a retaining wall 12 feet high, 8 inches wide at the top, 16 inches wide at the bottom, and 25 feet 6 inches long. (Figure to the nearest $\frac{1}{2}$ cubic yard.) 3. ________

4. Determine the equal spacing center to center of eight posts 3$\frac{1}{2}$ inches square if the distance from the outside of the first post to the outside of the last post is 37 feet 4$\frac{7}{8}$ inches. (Answer in feet and inches, with the fractional part of an inch expressed as a common fraction.) 4. ________

Topic 7—Decimal and Fractional Equivalents

1. Convert 0.1875 inch to 16ths of an inch. 1. ________

2. Convert 9 feet 6$\frac{1}{2}$ inches to feet and the decimal part of a foot. 2. ________

3. Convert 78.666 feet to feet and inches. 3. ________

4. Express 275 percent as a decimal. 4. ________

Topic 8—Perimeters, Areas, and Volumes

1. Determine the length of form material needed for a circular flower bed 3 feet 6 inches in diameter. (Figure to the nearest 16th of an inch.) 1. ________

2. Determine the number of squares of shingles (a square is 100 sq. ft.) needed to cover a hip roof of a building 32 feet 0 inches x 52 feet 0 inches if the length of the common rafter (a sloped rafter running from the peak of the roof to the edge of the building or to the overhang of the building) is 18 feet 0 inches, including overhang. 2.________

3. Calculate the number of cubic yards of earth to be excavated for an elliptically shaped swimming pool 26 feet 0 inches long, 18 feet 0 inches wide, and an average of 6 feet 0 inches deep. (Volume of ellipse = Diameter × diameter × 0.7854 × depth.) 3.________

4. Determine the cubic feet of storage space in a silo that has an outside diameter of 23 feet 6 inches, a height of 42 feet 0 inches, and a wall thickness of 8 inches. 4.________

Topic 9–Squares and Square Root

1. Determine the longest diagonal of an L-shaped building that has perimeter measurements of 33 feet 6 inches, 21 feet 3 inches, 12 feet 3 inches, 12 feet 3 inches, 21 feet 3 inches, and 33 feet 6 inches. (Answer in feet and inches to the nearest 16th of an inch.) 1.________

2. Three guy wires are to be placed 20 feet out from the base of a pole and attached to the pole 30 feet off the ground. Determine the total length of cable required for the three guy wires if 3 1/3 feet are allowed for the fastening of each cable. (Order to the next 5-ft. module.) 2.________

Topic 10–The Right Triangle

1. The tread run of a stair is 10 1/2 inches, and the tread rise is 6 7/8 inches. Determine the total length of a stair rail in a stair with 14 treads if it begins plumb above the first riser and ends plumb above the last riser. (Use the framing square and the 12ths scale.) 1.________

Topic 11–Lumber Products and Board Measure

1. Determine the number of board feet contained in 144 pieces 2 inches by 4 inches by 8 feet. 1.________

Topic 12–Metric Measurements and Conversion

1. Convert 36 metres to decametres. 1.________

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Mathematics

TOPIC 1 – WHOLE NUMBERS

This topic is planned to help you answer the following questions:

- What is the main cause of errors in addition?
- What is the best mathematical function to use in finding an unknown when the whole number and one of its two parts are known?
- What is the best way to find the sum of several numbers when they are all the same?
- How does one determine the number of times one number is contained in another number?

Addition

To a carpenter addition is the most important mathematical function, for a carpenter uses addition more frequently than any other mathematical process. The process of addition of whole numbers is generally well known and well understood, but errors in addition do occur, perhaps more through carelessness than through a lack of understanding of the operation.

Many errors in addition are caused also by faulty arrangement of numbers when a problem is written down. Care must be taken to arrange the columns of figures in the correct order, with units placed over units, tens over tens, hundreds over hundreds, and so forth, as shown in Fig. 1-1.

Digit or place names							
Ten millions	Millions	Hundred thousands	Ten thousands	Thousands	Hundreds	Tens	Unit
					2	3	4
						5	6
				5	7	8	9
							4
						8	5

Fig. 1-1. Placement of whole numbers for addition

The result of an addition problem is called the ***sum,*** and the numbers added are called ***addends.*** The accuracy of one's addition may be checked by adding the figures in the direction opposite from that first used. The result of an exercise in addition is not affected by the order in which the addends are added. Problem: Determine the total square footage of a house if the garage contains 328 square feet and the remainder of the house contains 1,299 square feet.

Garage	328 sq. ft.	(Addend)
Remainder of house	+ 1,299 sq. ft.	(Addend)
	1,627 sq. ft.	(Sum)

Subtraction

Subtraction, the reverse of addition, is valuable in determining an unknown quantity when the whole and one of its two parts are known.

In a subtraction problem the number from which another is to be subtracted is called the ***minuend,*** the number to be subtracted is the ***subtrahend;*** and the result is called the ***difference*** or ***remainder.*** The result of a subtraction operation can be checked by adding the difference to the subtrahend; the answer should be equal to the minuend. Problem: Determine how many of 500 precut studs were used on a job if a count shows that only 15 remained when the job was completed.

On hand at start of job	500	(Minuend)
Left over at completion	– 15	(Subtrahend)
Number of studs used	485	(Difference)

Multiplication

Multiplication can be thought of as a fast way to perform addition when all the numbers to be added are the same. A carpenter may frequently use multiplication in calculating length, area, or volume. Accuracy and speed in multiplication depend to a great extent on mastery of the multiplication tables shown in Table 1-1.

In a multiplication problem the number to be multiplied is called the ***multiplicand,*** and the number by which it is to be multiplied is the ***multiplier.*** Each of these numbers is also called a factor (any number used to determine the solution to a multiplication operation). The order in which the numbers are multiplied has no effect on the answer, called the ***product.*** Dividing the product by either factor is a method of checking in multiplication; the answer should be equal to the other factor. Problem: If a picket fence is to be 38 feet long and 5 pickets are required per lineal foot, determine the total number of pickets needed to construct the fence.

Total feet of fence	38	(Multiplicand)
Pickets per foot	X 5	(Multiplier)
Total pickets needed	190	(Product)

NOTE: In computing the answer to this problem, note that the beginning lineal foot in the 38-foot fence contains an additional picket. Therefore, the correct answer is actually 190 + 1 = 191 pickets.

Division

The division process is used to determine how many times one number is contained in another number. Skill with this process is frequently needed by a carpenter in performing layout work, usually in a situation in which a great deal of accuracy is required. For example, a carpenter would use division to determine the number of risers to be used for a stairway of a given height or to determine the unit cost of an item when the total cost and the number of units are known.

In a division problem, the number to be divided is the ***dividend,*** and the number by which the dividend is to be divided is called the ***divisor.*** The solution to a division problem is called the ***quotient.*** In cases in which the dividend cannot be divided an exact number of times, the quantity left over is called the ***remainder.*** The accuracy of a quotient can be checked by multiplying the quotient by the divisor; the product should be equal to the dividend. Problem: If a box of 12 cabinet pulls costs $4.20, determine the cost per pull.

	$ 0.35	(Quotient)
(Divisor) 12	$ 4.20	(Dividend)

TABLE 1-1

Multiplication Tables

1 X 1 = 1	2 X 1 = 2	3 X 1 = 3
1 X 2 = 2	2 X 2 = 4	3 X 2 = 6
1 X 3 = 3	2 X 3 = 6	3 X 3 = 9
1 X 4 = 4	2 X 4 = 8	3 X 4 = 12
1 X 5 = 5	2 X 5 = 10	3 X 5 = 15
1 X 6 = 6	2 X 6 = 12	3 X 6 = 18
1 X 7 = 7	2 X 7 = 14	3 X 7 = 21
1 X 8 = 8	2 X 8 = 16	3 X 8 = 24
1 X 9 = 9	2 X 9 = 18	3 X 9 = 27
1 X 10 = 10	2 X 10 = 20	3 X 10 = 30
1 X 11 = 11	2 X 11 = 22	3 X 11 = 33
1 X 12 = 12	2 X 12 = 24	3 X 12 = 36
4 X 1 = 4	5 X 1 = 5	6 X 1 = 6
4 X 2 = 8	5 X 2 = 10	6 X 2 = 12
4 X 3 = 12	5 X 3 = 15	6 X 3 = 18
4 X 4 = 16	5 X 4 = 20	6 X 4 = 24
4 X 5 = 20	5 X 5 = 25	6 X 5 = 30
4 X 6 = 24	5 X 6 = 30	6 X 6 = 36
4 X 7 = 28	5 X 7 = 35	6 X 7 = 42
4 X 8 = 32	5 X 8 = 40	6 X 8 = 48
4 X 9 = 36	5 X 9 = 45	6 X 9 = 54
4 X 10 = 40	5 X 10 = 50	6 X 10 = 60
4 X 11 = 44	5 X 11 = 55	6 X 11 = 66
4 X 12 = 48	5 X 12 = 60	6 X 12 = 72
7 X 1 = 7	8 X 1 = 8	9 X 1 = 9
7 X 2 = 14	8 X 2 = 16	9 X 2 = 18
7 X 3 = 21	8 X 3 = 24	9 X 3 = 27
7 X 4 = 28	8 X 4 = 32	9 X 4 = 36
7 X 5 = 35	8 X 5 = 40	9 X 5 = 45
7 X 6 = 42	8 X 6 = 48	9 X 6 = 54
7 X 7 = 49	8 X 7 = 56	9 X 7 = 63
7 X 8 = 56	8 X 8 = 64	9 X 8 = 72
7 X 9 = 63	8 X 9 = 72	9 X 9 = 81
7 X 10 = 70	8 X 10 = 80	9 X 10 = 90
7 X 11 = 77	8 X 11 = 88	9 X 11 = 99
7 X 12 = 84	8 X 12 = 96	9 X 12 = 108
10 X 1 = 10	11 X 1 = 11	12 X 1 = 12
10 X 2 = 20	11 X 2 = 22	12 X 2 = 24
10 X 3 = 30	11 X 3 = 33	12 X 3 = 36
10 X 4 = 40	11 X 4 = 44	12 X 4 = 48
10 X 5 = 50	11 X 5 = 55	12 X 5 = 60
10 X 6 = 60	11 X 6 = 66	12 X 6 = 72
10 X 7 = 70	11 X 7 = 77	12 X 7 = 84
10 X 8 = 80	11 X 8 = 88	12 X 8 = 96
10 X 9 = 90	11 X 9 = 99	12 X 9 = 108
10 X 10 = 100	11 X 10 = 110	12 X 10 = 120
10 X 11 = 110	11 X 11 = 121	12 X 11 = 132
10 X 12 = 120	11 X 12 = 132	12 X 12 = 144

Zero X any number = zero

MATHEMATICS

TOPIC 1 – WHOLE NUMBERS

Study Guide

Determine the correct answer for each of the following problems, and enter the result in the blank provided. If you rewrite and solve problems on a separate work sheet, be careful to align the numbers correctly.

1. 16 + 4 + 15 + 3 = __________
2. 5 + 18 + 17 + 9 = __________
3. 107 + 7 + 21 + 30 = __________
4. 1,232 + 5 + 396 + 124 = __________
5. 396 + 843 + 29 + 3,648 = __________
6. 937 – 721 = __________
7. 32 – 21 = __________
8. 921 – 32 = __________
9. 2,000 – 199 = __________
10. 6,348 – 5,189 = __________
11. 48 × 15 = __________
12. 236 × 47 = __________
13. 2,000 × 260 = __________
14. 536 × 103 = __________
15. 939 × 789 = __________
16. 5,680 × 83 = __________
17. 31,416 × 16 = __________
18. 7,854 × 89 = __________
19. 185 ÷ 5 = __________
20. 7,686 ÷ 21 = __________
21. 8,908 ÷ 34 = __________
22. 8,272 ÷ 752 = __________
23. 151,202 ÷ 173 = __________
24. 340 ÷ 10 = __________
25. 432 ÷ 48 = __________

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TOPIC 2 – FRACTIONS

This topic is planned to help you answer the following questions:

- **What are the various ways of expressing parts of a whole number?**
- **What is a common fraction?**
- **What is a mixed number?**
- **What are the procedures for adding, subtracting, multiplying, and dividing fractions?**

The term *fraction* means a part or portion of a whole quantity. To use any form of measurement without having a way to express fractional parts is practically impossible. As a carpenter you may be required to express fractional parts of many types of measurements, including fractional parts of a yard, foot, inch, or hour.

A fraction may be expressed in three different ways without changing its value, as a common fraction (3/4), as a decimal fraction (0.75), and as a percent (75%).

Common Fractions

As the word *common* implies, a ***common fraction*** is the type that is used most often in measurement. It is made up of a ***numerator*** and a ***denominator.*** The numerator and denominator are two numbers separated by a line that indicates division. The upper number is the numerator, and the bottom number is the denominator. A common fraction may be written in either of the two ways shown below:

$$3/4 \text{ or } \frac{3}{4} \begin{array}{l}\text{(Numerator)}\\ \text{(Denominator)}\end{array}$$

The denominator of a fraction indicates the number of equal parts into which the whole unit or figure is to be divided; the numerator indicates the number of these parts needed or being considered. In the fraction 3/4, a quantity is to be divided into four equal parts, and three of these parts are to be considered. (See Fig. 2-1.)

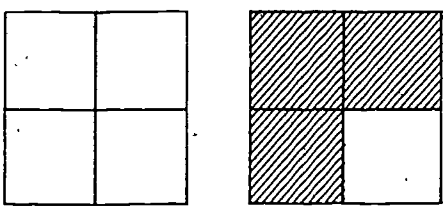

Fig. 2-1. The significance of the fraction 3/4

Common fractions may be either proper or improper. In a ***proper fraction*** the numerator is smaller than the denominator (1/4); an ***improper fraction*** has a numerator that is larger than the denominator (4/3).

Lowest Common Denominator

Some operations with fractions can be performed only when the fractions all have the same denominator. A like denominator for a number of fractions is called the ***lowest common denominator*** (LCD). It is the smallest number into which a number of denominators can be divided evenly. The lowest common denominator of 1/2, 1/4, and 1/8, for example, is readily seen to be 8, the lowest number into which all three denominators can be divided evenly.

Lowest Terms

Working with fractions or with numbers that include fractions is much easier if the fractions are reduced to their lowest terms; that is, if the numerator and denominator are divided by the largest number that can be divided evenly into both of them. Whenever the solution to a problem or operation includes a fraction, you should reduce the fraction to lowest terms. The fraction 9/12 can be reduced to lowest terms in the following manner:

$$\frac{9 \div 3}{12 \div 3} = \frac{3}{4} \text{ or } 3/4$$

Both the numerator and denominator of the fraction are divided by 3, the largest number that can be divided evenly into both of them. To reduce the numerator and denominator any further is impossible since the numerator and denominator cannot be divided evenly by any other common factor. The value of the fraction is not altered when the numerator and denominator are divided by the same number.

Addition of Fractions

Fractions can be added only when their denominators are the same; that is, when they have a common denominator.

Adding Fractions with Common Denominators

Fractions with common denominators are added by combining their numerators and placing the sum over the common denominator. The fractions $\frac{1}{12}$ and $\frac{5}{12}$ are added in the following manner:

$$\frac{1}{12} + \frac{5}{12} = \frac{1+5}{12} = \frac{6}{12}$$
$$= \frac{1}{2} \text{ (reduced to lowest terms)}$$

Adding Fractions with Unlike Denominators

Fractions with unlike denominators can be added only when they have been changed to equivalent values having a common denominator. To establish equivalent values for the fractions, divide the denominator of each one into the lowest common denominator, and multiply each numerator by the respective quotient. Then write each product over the common denominator. The new fractions have a common denominator and can be added as previously described. The fractions $\frac{1}{2}$ and $\frac{2}{3}$ can be added in the following manner:

$$\frac{1}{2} = \frac{3}{6} \left(6 \div 2 = 3, \text{ and } \frac{1 \times 3}{2 \times 3} = \frac{3}{6}\right)$$
$$\frac{2}{3} = \frac{4}{6} \left(6 \div 3 = 2, \text{ and } \frac{2 \times 2}{3 \times 2} = \frac{4}{6}\right)$$
$$\frac{3}{6} + \frac{4}{6} = \frac{7}{6} = 1\frac{1}{6} \text{ (reduced to lowest terms)}$$

Note that an improper fraction, such as $\frac{7}{6}$, is reduced to lowest terms by dividing the numerator by the denominator.

Adding Mixed Numbers

The combination of a whole number and a fraction, such as $1\frac{1}{4}$, is called a ***mixed number***. To add mixed numbers, add the whole numbers, add the fractions, and combine the two sums. The mixed numbers $7\frac{7}{15}$ and $1\frac{4}{15}$ are added in the following manner:

$$7\frac{7}{15} + 1\frac{4}{15} = 7 + 1 + \frac{7+4}{15} = 8\frac{11}{15}$$

Subtraction of Fractions

Fractions can be subtracted only when they have a common denominator.

Subtracting Fractions with Common Denominators

Fractions with common denominators are subtracted by finding the difference between the numerators and placing the result over the common denominator. The fraction $\frac{4}{9}$ can be subtracted from $\frac{7}{9}$ in the following manner:

$$\frac{7}{9} - \frac{4}{9} = \frac{7-4}{9} = \frac{3}{9}$$
$$= \frac{1}{3} \text{ (reduced to lowest terms)}$$

Subtracting Fractions with Unlike Denominators

Fractions with unlike denominators must be converted to fractions having a common denominator before one can be subtracted from the other. Subtraction is then carried out in the manner described above for subtracting fractions with common denominators.

Subtracting Mixed Numbers

To subtract one mixed number from another, subtract the whole numbers and the fractions separately. If the numerator of the fraction in the subtrahend is larger than the numerator of the fraction in the minuend, "borrowing" must be carried out in the minuend. In the case of subtracting $5\frac{5}{8}$ from $9\frac{3}{8}$, a quantity of 1 ($\frac{8}{8}$) must be borrowed from the 9 and added to the $\frac{3}{8}$ to make the numerator in the minuend larger than the numerator in the subtrahend. This borrowing reduces the whole number 9 to 8. Subtraction is then carried out by subtracting whole numbers from whole numbers and fractions from fractions, as in the following:

$$\begin{array}{r} 9\frac{3}{8} \\ -5\frac{5}{8} \\ \hline \end{array} = \begin{array}{r} 8\frac{11}{8} \\ -5\frac{5}{8} \\ \hline \end{array} = 3\frac{6}{8} = 3\frac{3}{4} \text{ (reduced to lowest terms)}$$

Multiplication of Fractions

The multiplication of common fractions does not require that the fractions have a common denominator.

Multiplying Two or More Fractions

When fractions are multiplied by fractions, the numerators are multiplied by numerators, the denominators are multiplied by denominators, and the product of the numerators is written over the product of the denominators. The following example illustrates how $\frac{2}{3}$ is multiplied by $\frac{3}{4}$:

$$\frac{2}{3} \times \frac{3}{4} = \frac{2 \times 3}{3 \times 4} = \frac{6}{12}$$
$$= \frac{1}{2} \text{ (reduced to lowest terms)}$$

Multiplying Mixed Numbers

In problems involving the multiplication of a mixed number, the mixed number should be changed to an improper fraction before the multiplication is carried out. To do this, multiply the whole number by the denominator of the fraction, add the product to the numerator, and write the sum over the denominator. The fraction $2\frac{3}{4}$ is changed to an improper fraction as follows:

$$2\frac{3}{4} = \frac{(2 \times 4) + 3}{4} = \frac{11}{4}$$

Once the mixed number has been changed to an improper fraction, multiplication is carried out in the manner described for multiplying two or more fractions.

Cancelling in Multiplying Fractions

The multiplication of fractions can be simplified by ***cancelling***—dividing any numerator and any denominator by some divisor that is common to both. The following example is provided to illustrate how cancelling can be done in the multiplication of $\frac{5}{8} \times \frac{2}{15}$:

$$\frac{\overset{1}{\cancel{5}}}{\underset{4}{\cancel{8}}} \times \frac{\overset{1}{\cancel{2}}}{\underset{3}{\cancel{15}}} = \frac{1 \times 1}{4 \times 3} = \frac{1}{12}$$

In this problem the numerator 5 and the denominator 15 are both divided by 5, and the numerator 2 and the denominator 8 are divided by 2. Multiplication is then carried out in the manner for multiplying one fraction by another.

Division of Fractions

As in the multiplication of common fractions, division of common fractions does not require conversion to a common denominator.

Dividing Fractions by Fractions

Whenever a fraction is to be divided by another fraction, the divisor must be inverted before the operation can be carried out. ***Inverting a fraction*** means turning it so that the numerator becomes the denominator and the denominator becomes the numerator. The fraction $\frac{9}{16}$ becomes $\frac{16}{9}$ when inverted. Once the divisor has been inverted, the fractions are *multiplied*, using the procedure previously shown for multiplication of fractions.

Dividing Mixed Numbers by Mixed Numbers

To divide one mixed number by another, change the mixed numbers to improper fractions, invert the divisor, and multiply the fractions in the manner previously described.

MATHEMATICS

TOPIC 2 – FRACTIONS

Study Guide

Determine the correct answer for each of the following problems, and enter the result in the blank provided. If you rewrite and solve problems on a separate work sheet, be careful to align the numbers correctly.

1. $\frac{1}{2} + \frac{1}{4}$ = ________
2. $\frac{1}{4} + \frac{9}{16}$ = ________
3. $\frac{11}{24} + \frac{5}{8}$ = ________
4. $\frac{4}{5} + \frac{3}{4}$ = ________
5. $\frac{11}{12} + \frac{9}{32}$ = ________
6. $2\frac{3}{8} + 3\frac{1}{4}$ = ________
7. $2\frac{1}{2} + 3\frac{9}{16} + 5\frac{1}{8}$ = ________
8. $23\frac{5}{8} + 13\frac{11}{16} + 4\frac{9}{24}$ = ________
9. $\frac{2}{3} - \frac{1}{3}$ = ________
10. $\frac{7}{8} - \frac{1}{2}$ = ________
11. $\frac{3}{4} - \frac{7}{12}$ = ________
12. $\frac{15}{16} - \frac{3}{4}$ = ________
13. $6 - 2\frac{3}{4}$ = ________
14. $13\frac{5}{8} - 5\frac{3}{4}$ = ________
15. $9\frac{3}{4} - 5\frac{5}{12}$ = ________
16. $6\frac{3}{10} - 4\frac{9}{16}$ = ________
17. $16\frac{5}{8} - 13\frac{1}{2}$ = ________
18. $9\frac{1}{4} - 5\frac{3}{8}$ = ________
19. $5\frac{5}{16} - 4\frac{3}{32}$ = ________
20. $2\frac{1}{8} - 1\frac{7}{8}$ = ________
21. $\frac{1}{2} \times \frac{1}{3}$ = ________
22. $\frac{7}{8} \times \frac{3}{8}$ = ________
23. $\frac{1}{2} \times \frac{2}{3}$ = ________
24. $\frac{2}{3} \times \frac{3}{4}$ = ________
25. $\frac{1}{2} \times \frac{2}{5}$ = ________
26. $\frac{1}{2} \div \frac{1}{5}$ = ________
27. $\frac{2}{3} \div \frac{5}{6}$ = ________
28. $\frac{4}{5} \div \frac{7}{20}$ = ________
29. $15 \div \frac{3}{8}$ = ________
30. $13 \div \frac{2}{3}$ = ________
31. $10 \div 1\frac{7}{8}$ = ________

Change the following mixed numbers to improper fractions:

32. $4\frac{3}{8}$ = ________
33. $5\frac{9}{16}$ = ________
34. $4\frac{7}{8}$ = ________
35. $16\frac{1}{3}$ = ________

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TOPIC 3 – DECIMALS

This topic is planned to help you answer the following questions:

- **What is the most common problem encountered in working with decimals?**
- **What is the rule for placing the decimal point in the answers of addition and subtraction problems?**
- **How is the position of the decimal point determined in the product of a multiplication problem and in the quotient of a division problem?**

Decimal fractions, or simply decimals, are fractions in which only the numerator is expressed. The denominator is understood to be ten or some multiple of ten (100, 1,000, 10,000, and so forth) and is represented by the use of the decimal point. The value of the unexpressed denominator in a decimal fraction depends on how many numbers occupy places to the right of the decimal point; that is, on how many numbers are in the numerator. The following are some examples of decimal fractions with different denominators:

0.3 = three tenths
0.03 = three hundredths
0.003 = three thousandths
0.0003 = three ten thousandths

Fractional parts of units are often expressed in decimals. Because the monetary system of the United States is based on the decimal system, a thorough understanding of decimals is essential for anyone who deals in dollars and cents. For you as a carpenter, this understanding is vital also because of the many instances in which you will have to perform addition, subtraction, multiplication, and division with decimals.

Many of the errors that are made in work involving decimals are the result of misaligned or misplaced decimal points. You must take great care, therefore, to make sure that you place the decimal point correctly when you write a problem and its solution.

Addition

Decimals are added in the same way that whole numbers are added, with the exception that the decimal point is included in each of the addends and in the sum. The decimal points must be aligned vertically in the addends and in the sum. A good practice to follow in working with decimals is that of adding zeros where necessary to the right of the decimal point so that each number has the same number of decimal places. Addition of the numbers 3.73, 74.5, 0.05, and 1.25 is carried out in the following manner:

```
   3.73
  74.50
   0.05
+  1.25
  -----
  79.53
```

Subtraction

Decimals are subtracted in the same manner that whole numbers are subtracted, with the decimal points aligned vertically in the minuend, subtrahend, and remainder. Again, you should add zeros where necessary to the right of the decimal point to give both the minuend and subtrahend the same number of decimal places. The number 63.733 is subtracted from 98.55 in the manner shown below:

```
  98.550
- 63.733
  ------
  34.817
```

Multiplication

Except for the special treatment required in placing the decimal point in the product, the multiplication process used with decimals is the same as that used for multiplying whole numbers. Placement of the decimal point in the product can be done only after the multiplication has been completed. The number of decimal places in the multiplicand and multiplier are counted, and the decimal point is then inserted that number of places from the right in the product. If the number of decimal places counted is greater than the number of digits in the product, enough zeros must be added at the left of the product so that the decimal point can be placed the correct number of places from the right. The example that follows shows how 85.5 is multiplied by 0.26:

$$\begin{array}{r} 85.5 \\ \times 0.26 \\ \hline 5130 \\ +1710 \\ \hline 22.230 \end{array}$$

Division

In division of decimals, the divisor should be converted to a whole number by moving its decimal point to the extreme right; the decimal point in the dividend should also be moved the same number of places to the right. If the dividend has fewer digits than the divisor, zeros are added to the dividend so that both have at least the same number of digits. Additional zeros can be added in the dividend if it is desired that the quotient be carried out to an even greater number of decimal places. The decimal point in the quotient is placed directly over the decimal point in the dividend, and division is carried out in the manner used for division of whole numbers. The following example indicates how 48 is divided by 0.08:

$$0.08\overline{)48} = 0.08.\overline{)48.00.} \quad (\text{quotient } 6\,00.)$$

Rounding Off of Decimals

Rounding off numbers is desirable in situations that require only an approximate figure; that is, when an extremely high degree of accuracy is not necessary. When any number is rounded off, the implication is that the number used is accurate enough for practical purposes.

The process of rounding off numbers is used most frequently with decimals. The number 647.42857, for example, is carried out five decimal places. This indicates a high degree of accuracy but may be more than is really required by certain circumstances. In a situation that calls for accuracy in tenths, a decision should be made as to whether the number is closer to being 647.4 or 647.5. The following rules for rounding off numbers can be used to reach a conclusion:

1. If the first digit to be dropped is less than five, the last digit to be kept is left as it is.
2. If the first digit to be dropped is greater than five, the last digit to be kept is increased by one.
3. If the first digit to be dropped is five, the last digit to be kept is generally increased by one.

The number 647.42857 rounded off to the nearest tenth is, therefore, 647.4; to the nearest hundredth, 647.43; to the nearest thousandth, 647.429. To the nearest whole number, 647.42857 is rounded off to 647.

Study Guide

Determine the correct answer for each of the following problems, and enter the result in the blank provided. If you rewrite and solve problems on a separate work sheet, be careful to align the numbers correctly.

1. $2.53 + $5.36 + $0.29 + $23.58 = ______
2. 0.17 + 5.3 + 0.53 + 9.632 = ______
3. 4.92 + 4.001 + 24.4 + 253.08 = ______
4. $94.00 + $0.85 + $5.80 + $8.41 = ______
5. 6 + 3.3 + 0.37 + 200.0 = ______
6. 0.38 – 0.26 = ______
7. 4.23 – 3.34 = ______
8. 3.7 – 0.24 = ______
9. 1.0 – 0.17 = ______
10. $20 – $10.98 = ______
11. 0.25 X 0.06 = ______
12. 1.3 X 0.2 = ______
13. 5.7 X 2.5 = ______
14. 1.15 X 0.003 = ______
15. 35 X 0.202 = ______
16. 36.36 ÷ 6 = ______
17. 36.0 ÷ 0.6 = ______
18. 3.636 ÷ 0.06 = ______
19. 420.05 ÷ 0.62 = ______
20. 363.6 ÷ 0.006 = ______
21. 0.13 to the nearest tenth = ______
22. 5.17 to the nearest tenth = ______
23. 0.986 to the nearest tenth = ______
24. 0.627 to the nearest hundredth = ______
25. 7.847 to the nearest hundredth = ______
26. 43.4025 to the nearest hundredth = ______
27. 0.4997 to the nearest thousandth = ______
28. 3.0349 to the nearest thousandth = ______
29. 4.0074 to the nearest thousandth = ______
30. 51.4999 to the nearest whole number = ______

Write these figures containing decimal fractions as word statements (Example: 12.7 = twelve and seven-tenths):

31. 0.36 = ______
32. 127.57 = ______
33. 0.05 = ______
34. 1.5 = ______
35. 15.015 = ______

TOPIC 4 — PERCENT

This topic is planned to help you answer the following questions:

- **What is meant by the terms *percent* and *percentage?***
- **For what purposes are percents most useful?**
- **With what basic terms must you be familiar to solve problems involving percent?**

The word ***percent*** is an abbreviation of the Latin *per centum* and literally means "for each hundred" or "by the hundred." The term ***percentage*** means the method of expressing a part of a whole as hundredths of a whole. Thus, 12 percent means 12 parts of a whole that is thought of as consisting of 100 parts; 100 percent means all 100 parts of the whole taken together; and 108 percent means all 100 parts of the whole, plus 8 more such parts.

Percents are often used in determining profit and loss, discounts, amounts of taxes, and interest on loans. Knowledge of the rules and procedures for solving the many kinds of percentage problems is, therefore, indispensable in your work as a carpenter.

Conversion of Percents to Common Fractions and Decimals

Since percents are expressions of the parts of a whole, they can be converted to common fractions or to decimals. Any percent can be changed to a fraction by removing the percent sign and writing the number over the denominator 100. As a fraction, 25 percent is equivalent to $^{25}/_{100}$; 100 percent is equivalent to $^{100}/_{100}$ or 1.0; and 108 percent is equivalent to $^{108}/_{100}$ or $1^{8}/_{100}$ ($1^{2}/_{25}$ reduced to lowest terms).

To convert a percent to a decimal, remove the percent sign, and move the decimal point two places to the left (36% = 0.36). This process can be used in reverse to change a decimal to a percent. The decimal 0.06, for example, becomes 6% by moving the decimal point two places to the right and affixing the percent sign.

Conversion of Common Fractions to Percents

In the conversion of a common fraction to a percent, the fraction must first be changed to a decimal fraction by dividing the numerator by the denominator. For example, $^{1}/_{4}$ = 1.00 ÷ 4 = 0.25. Conversion to a percent is then completed by moving the decimal point two places to the right and adding the percent sign, as previously described.

Terms and Formulas Used in Percent Problems

Workers who must solve problems involving percents should be familiar with the following terms and definitions:

1. *Base (B)* is the number on which percent is computed. The base may be the rental price of an article, the total number of square feet to be covered, the principal amount of a loan, or the like.
2. *Rate (R)* is the number of hundredths of the base to be considered (the number with the percent sign).
3. *Percentage (P)* is the number of hundredths of the base as indicated by the rate. Percentage is the product obtained by multiplying the base by the rate.
4. *Difference (D)* is the remainder after the percentage is subtracted from the base.
5. *Amount (A)* is the sum of the base and the percentage. It is, for example, the total amount of material needed to cover a given area, including waste allowance, or the total amount to be repaid in the case of a loan (principal plus interest). It may also be the total selling price, including costs, percent of profit, and so forth.

The task of determining the base, rate, percentage, difference, or amount in a percent problem can be much simplified through the use of some fundamental rules or formulas. These rules may be stated as follows:

1. $B = P \div R$
2. $B = A \div (1.0 + R)$
3. $B = D \div (1.0 - R)$
4. $R = P \div B$
5. $P = B \times R$
6. $D = B - P$
7. $D = B \times (1.0 - R)$
8. $A = B + P$
9. $A = B \times (1.0 + R)$

Common Percent Problems

Three common types of percent problems that you may have to solve are those that involve (1) percent of gain or loss; (2) amounts of material to order, including waste allowance; and (3) discounts.

Percent of Gain or Loss

In many instances finding the gain or loss in percent may be desirable. If so, you should follow this procedure: (1) find the difference between the initial and final values; and (2) divide this difference by the final value. For example, the percent of gain on a lot that was purchased for $1,600 and later sold for $2,400 is 33⅓ percent ($2,400 − $1,600 = $800, and $800 ÷ $2,400 = 33⅓ percent).

Amounts of Material to Order

In computations to determine amounts of materials to order, including allowance for waste, the base (the number of square feet in the area under consideration) is multiplied by the percent of waste allowance, and this product (the percentage of waste) is then added to the base. For example, if the mill and end waste allowance of the material to be used is 15 percent and an area of 300 square feet is to be covered, a total of 345 square feet of material should be ordered (300 sq. ft. X 0.15 = 45 sq. ft. of waste, and 300 sq. ft. + 45 sq. ft. = 345 sq. ft.). *NOTE:* Although this method for determining amounts to order will yield a result that is not mathematically exact, the procedure is nevertheless accepted for use within the carpentry trade. The percent of allowance for waste is set higher than that which will actually result, thereby ensuring that the amount of material to be ordered will be at least enough to cover the area under consideration.

Another, more direct method of solving problems of this type is to use the following rule: amount = base multiplied by the sum of 1.0 plus the rate, or $A = B \times (1.0 + R)$.

Discounts

In the calculation of discount, the base price is multiplied by the rate of discount, and then the product of this operation (the percentage) is subtracted from the base price. The difference represents the actual selling price. For example, a carpenter who receives a 20 percent discount on a joiner plane that is sold at a retail price of $20 will actually pay only $16 for the tool ($20 X 0.20 = $4, and $20 − $4 = $16).

MATHEMATICS

TOPIC 4 – PERCENT

Study Guide

Determine the correct answer for each of the following problems, and enter the result in the blank provided.

Express the following percents as decimal fractions:

1. 25 percent = ________
2. 2.5 percent = ________
3. 0.25 percent = ________
4. 2,500 percent = ________
5. 20.05 percent = ________

Express the following decimal fractions as percents:

6. 0.75 = ________
7. 0.11 = ________
8. 0.111 = ________
9. 0.05 = ________
10. 0,333 = ________

Express the following fractions as percents:

11. $\frac{1}{8}$ = ________
12. $\frac{1}{3}$ = ________
13. $\frac{1}{4}$ = ________
14. $\frac{3}{4}$ = ________
15. $\frac{2}{3}$ = ________

Express the following percents as common fractions:

16. 25 percent = ________
17. 5 percent = ________
18. 20 percent = ________
19. 80 percent = ________
20. $33\frac{1}{3}$ percent = ________

Determine the answers to the following word problems:

21. A list of hardware is retail priced at $62.50, with a discount of 15 percent. What is the net price? 21.________
22. If the profit earned on a sale of property is $1,140 and the rate of profit is 12 percent, what is the selling price of the property? 22.________
23. Employees in a certain pay class were earning $3.62 per hour. Their pay was increased $6\frac{1}{2}$ percent. What was their new pay rate? 23.________
24. An area to be covered is 240 square feet. Milling and end waste is determined to be 18 percent. How many square feet of lumber should be ordered to cover this area? 24.________
25. An apprentice carpenter purchased some tools at a discount of 16 percent. If the regular price of the tools was $17.95, what amount did the apprentice have to pay? 25.________

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TOPIC 5 – CONVERSION OF UNITS

This topic is planned to help you answer the following questions:

- **How are most commodities measured?**
- **Why is it necessary in multiplying and dividing compound numbers to convert inches into a fractional part of a foot?**
- **How can feet and inches be changed to feet?**
- **How can inches be converted to decimal parts of a foot?**

For purposes of buying and selling, most commodities are measured in some standard unit of measure. Gasoline, for example, is usually bought and sold by the gallon in the United States. Working with standard units of measure, however, may not always be desirable or convenient; and a carpenter, like other workers, may find that the ability to solve problems of measurement quickly and easily is dependent on the degree of skill with which he or she is able to convert measurements from one type of unit to another. (See Table 5-1 for a list of some common measurements, weights, and conversion equivalents.)

Conversion to Common Fractions and Mixed Numbers

In the solving of problems that include more than one unit of measure, all quantities should first be converted to quantities of the same unit of measure. Finding the area of a surface 9 feet by 3 feet 6 inches can be done by converting both measurements to inches or by changing both to feet.

Since 1 foot is equal to 12 inches, 9 feet can be converted to 108 inches (9 X 12 in. = 108 in.); and 3 feet 6 inches can be converted to 42 inches (3 X 12 in. = 36 in., and 36 in. + 6 in. = 42 in.).

TABLE 5-1

Common Weights and Measures

Linear	12 inches	=	1 foot
	3 feet	=	1 yard
	5,280 feet	=	1 mile
Area	144 square inches	=	1 square foot
	9 square feet	=	1 square yard
	43,560 square feet	=	1 acre
	640 acres	=	1 square mile
Volume	1,728 cubic inches	=	1 cubic foot
	27 cubic feet	=	1 cubic yard
Liquid	1 pint	=	16 fluid ounces
	2 pints	=	1 quart (32 fluid ounces)
	4 quarts	=	1 gallon (128 fluid ounces)
	7.48 gallons	=	1 cubic foot
Dry	2 pints	=	1 quart (67.2 cubic inches)
	4 quarts	=	1 gallon (268.8 cubic inches)
	6.43 gallons	=	1 cubic foot
Weight	16 drams	=	1 ounce
	16 ounces	=	1 pound
	2,000 pounds	=	1 short ton
	2,240 pounds	=	1 long ton

Changing 3 feet 6 inches to a quantity expressed only in feet can be done by converting the number of inches to a common fraction and then converting the entire quantity to a mixed number; that is, to a whole number and a common fraction. Restated as a mixed number, 3 feet 6 inches becomes $3\frac{1}{2}$ feet (3 ft. 6 in. = $3\frac{6}{12}$ ft. = $3\frac{1}{2}$ ft.).

Conversion to Decimal Fractions

At times you may be required to solve problems in which the use of decimal fractions is preferable to the use of common fractions. A dimension of 9 inches, for example, can also be thought of as 0.75 foot ($\frac{9}{12} = \frac{3}{4}$, and $3 \div 4 = 0.75$).

MATHEMATICS

TOPIC 5 – CONVERSION OF UNITS

Study Guide

Determine the correct answer for each of the following problems, and enter the result in the corresponding blank at the right.

1. Convert 16 feet 8 inches to inches. 1.________
2. Convert 118 inches to feet and inches. 2.________
3. Convert 216 cubic feet to cubic yards. 3.________
4. Convert 76,230 square feet to acres. 4.________
5. Convert 65 yards to feet. 5.________
6. Convert 59,620 cubic feet to cubic yards and decimal parts of a cubic yard. 6.________
7. Convert 69 feet 10 inches to feet and decimal parts of a foot. 7.________
8. Convert 520 inches to feet and decimal parts of a foot. 8.________
9. Convert 65½ cubic yards to cubic feet and decimal parts of a cubic foot. 9.________
10. Convert 320¾ cubic feet to cubic yards and decimal parts of a cubic yard. 10.________

TOPIC 6 — COMPOUND NUMBERS

This topic is planned to help you answer the following questions:

- **What is meant by a compound number?**
- **How are dimensions not shown on the plans obtained?**
- **How are compound numbers added and subtracted?**
- **How is the multiplication of one compound number by another performed?**
- **How is division done when the dividend is a compound number?**

The term ***compound number*** as used in this topic is defined as a number that includes more than one unit of measure, such as 6 feet 9 inches, 8 pounds 20 ounces, or 2 hours 10 minutes.

Addition

Two methods may be used in the adding of compound numbers:

1. Reduce the given quantities to the smallest unit of measure in the problem, and then add the numbers. The result can be left as it is, or it can be converted to the greater unit of measure, whichever is desired.
2. Carry out the addition of the numbers as they are given, making any needed conversions or reductions during the process of adding.

If the first method described above is used to add 6 feet 9 inches and 2 feet 4 inches, both quantities should be expressed in inches before the addition is performed. The quantity 6 feet 9 inches becomes 81 inches (6 X 12 in. = 72 in., and 72 in. + 9 in. = 81 in.). In like manner, 2 feet 4 inches is then converted to 28 inches, and the two figures are added (81 in. + 28 in. = 109 in.). The sum, 109 inches, can be used as it is; or it can be converted to $9\frac{1}{12}$ feet or 9 feet 1 inch (109 in. ÷ 12 = $9\frac{1}{12}$ ft. or 9 ft. 1 in.).

In the use of the second method described above, inches are added to inches; the sum of the addition of inches is reduced (converted), if necessary; and then feet are added to feet, including any number of feet resulting from the conversion of the sum of the inches. In the addition of 6 feet 9 inches and 2 feet 4 inches, the sum of the inches is found to be 13 inches (9 in. + 4 in. = 13 in.). This sum is converted to 1 foot 1 inch (13 in. ÷ 12 = 1 ft. 1 in.); and the sum of the number of feet, including the 1 foot obtained in the conversion, is determined to be 9 feet (6 ft. + 2 ft. + 1 ft. = 9 ft.). The two sums are then combined to give a result of 9 feet 1 inch. This same problem might also be written as follows:

(1)

6 ft.	9 in.
+ 2 ft.	4 in.
	13 in.
9 ft.	1 in.

Subtraction

The ability to subtract one compound number from another can be very useful to you as a carpenter, especially when you may have to work with plans that do not include all needed dimensions. Given an overall dimension (for example, 10 ft. 9 in.) and a part (4 ft. 8 in., for example) of the overall dimension, you can determine the unstated part of the overall dimension by subtracting the known part from the whole.

In the subtraction of one compound number from another, either of the two methods described for addition of compound numbers may be used; that is, the two quantities can be converted to the same unit of measure before subtraction is performed, or any necessary conversions can be made during the subtraction of the numbers as given. *NOTE:* In problems in which digits in the subtrahend are larger than corresponding digits in the minuend, borrowing (conversion) must be carried out before the subtraction can be performed. In the subtraction of 5 feet 9 inches from 19 feet 8 inches, the 9 inches in the subtrahend cannot be subtracted from the 8 inches in the minuend. Thus, 1 foot, or 12 inches, must be borrowed in the minuend. The 12 inches are added to the given number of inches, and the number of feet is decreased by one. The problem can then be viewed as the subtraction of 5 feet 9 inches from 18 feet 20 inches, as shown below:

18 ft.	20 in.
− 5 ft.	9 in.
13 ft.	11 in.

Multiplication

Multiplication is the mathematical process used to determine area, volume, and sometimes total length. For carpenters this process often involves one or more compound numbers.

In the multiplication of compound numbers, any necessary reductions or conversions can be made during or after the multiplication. The recommended procedure is to make reductions or conversions after the completion of the multiplication.

To multiply a compound number by a mixed number, multiply each unit of measure separately, and then reduce or convert if necessary. Multiplying 2 feet 3 inches by 5 is therefore accomplished by multiplying 3 inches by 5 (3 in. X 5 = 15 in.) and multiplying 2 feet by 5 (2 ft. X 5 = 10 ft.). The product, 10 feet 15 inches, is then converted to 11 feet 3 inches. If the solution to this problem were to be expressed to the next even foot (as in determining how many board feet to purchase), the product would be increased to 12 feet.

The multiplication of one compound number by another is more difficult than that involved in multiplying a compound number by a whole number. Before one compound number can be multiplied by another, both numbers *must* be converted to the same unit of measure. For example, to multiply 6 feet 9 inches by 7 feet 4 inches, convert the dimensions either to feet only or to inches only before multiplying.

The unit of measure desired in the answer will be the deciding factor in determining which unit to convert. If the problem stated above were one of calculating floor area, the preferred conversion would be to feet since floor area is generally expressed in square feet. The 6 feet 9 inches converted to feet would be $6\frac{9}{12}$ feet or $6\frac{3}{4}$ feet or 6.75 feet. The 7 feet 4 inches converted to feet would be $7\frac{4}{12}$ feet or $7\frac{1}{3}$ feet or 7.33 feet. The multiplication of the two measurements may be done by using fractions or decimals, but less difficulty is generally encountered if decimal fractions are used, as in the following:

```
      6.75  ft.
    X 7.33  ft.
    ---------
      2025
     2025
  + 4725
  ----------
   49.4775 , or 49.5 (49½) sq. ft.
```

For the purpose of *estimating* areas, carpenters often convert dimensions to the nearest whole foot before multiplying. The dimension 6 feet 9 inches would be considered as 7 feet, and 7 feet 4 inches would become 7 feet. The product 49 square feet (7 ft. × 7 ft. = 49 sq. ft.) is accurate enough as an estimate.

Division

In division involving compound numbers, generally a compound number is the dividend, and a whole number is the divisor. In very few instances are both the dividend and divisor compound numbers.

Before the division can be done, the compound number should be converted to a value expressed in a single unit of measure. The quantity 9 feet 8 inches, for example, can be converted to 116 inches (12 in. X 9 = 108 in., and 108 in. + 8 in. = 116 in.); to $9\frac{2}{3}$ feet (9 ft. 8 in. = $9\frac{8}{12}$ ft. = $9\frac{2}{3}$ ft.); or to 9.67 ft. ($9\frac{2}{3}$ ft. = $\frac{29}{3}$ ft. = 29 ÷ 3 = 9.67 ft.). The recommended procedure is to convert the feet and inches to inches only to avoid having to work with any type of fraction. In the determination, then, of the unit of rise in a stairway that has 16 risers and a total rise of 9 feet 8 inches, the recommended procedure is to divide 116 inches by 16 (116 in. ÷ 16 = $7\frac{1}{4}$ in.).

MATHEMATICS

TOPIC 6 – COMPOUND NUMBERS

Study Guide

Determine the correct answer for each of the following problems, and enter the result in the corresponding blank at the right.

1. Add 15 feet 4 inches, 12 feet 8 inches, 13 feet 9 inches, and 20 feet, 10 inches. 1. ________
2. Add 5 yards 2 feet 8 inches, 7 yards 1 foot 6 inches, and 12 yards 2 feet 0 inches. 2. ________
3. Add 11 pounds 14 ounces, 5 pounds 2 ounces, 6 pounds 12 ounces, and 3 pounds 0 ounces. 3. ________
4. Add 25 degrees 10 minutes, 13 degrees 3 minutes, 45 degrees 50 minutes, and 10 degrees 0 minutes. 4. ________
5. Subtract 21 feet 6 inches from 23 feet 10 inches. 5. ________
6. Subtract 4 feet 9 inches from 13 feet 6 inches. 6. ________
7. Subtract 2 yards 1 foot 5 inches from 5 yards 2 feet 10 inches. 7. ________
8. Subtract 5 yards 2 feet 10 inches from 12 yards 1 foot 6 inches. 8. ________
9. Subtract 2 hours 18 minutes from 3 hours 40 minutes. 9. ________
10. Subtract 30 degrees 30 minutes from 60 degrees 0 minutes. 10. ________
11. Multiply 3 feet 8 inches by 6. 11. ________
12. Multiply 17 feet 9 inches by 14. 12. ________
13. Multiply 4 feet 4 inches by 15 feet 9 inches. 13. ________
14. Divide 11 feet 6 inches by 3. 14. ________
15. Divide 19 feet 3 inches by 3. 15. ________
16. Divide 6 hours 48 minutes by 4. 16. ________
17. Divide 120 feet 28 inches by 4. 17. ________
18. Divide 25 pounds 15 ounces by 5. 18. ________
19. Divide 88 feet 10 inches by 13. 19. ________
20. Divide 50 feet 2 inches by 14. 20. ________

TOPIC 7 – DECIMAL AND FRACTIONAL EQUIVALENTS

This topic is planned to help you answer the following questions:

- What is meant by the expression *finding the equivalent?*
- What is the smallest division of an inch on the carpenter's tape?
- How is a decimal fraction converted to a common fraction?

Some of the information presented in this topic was also included in Topic 4. Repetition of this material is intended to (1) provide a review of the information covered in the earlier topic; and (2) serve as a base for the introduction of additional material dealing with fractions.

Fractional Parts of Units

Carpenters deal with fractional parts (less than a whole) in most of their work. These fractional parts may be parts of a number of units of measurement: yards, feet, or inches; units of an angle, including degrees, minutes, and seconds; units of time expressed in hours, minutes, or seconds; and so forth. Any of these units, broken into fractional parts, may be expressed as a common fraction (½, ¼, ⅛), as a decimal fraction (0.5, 0.25, 0.125), or as a percent (50 percent; 25 percent, 12½ percent).

Conversion of Fractions

Changing a fraction from one form to another may be either desirable or necessary. The process of conversion from one form to another is called "finding the equivalent."

Any type of fraction can be changed to any of the other types; that is, a common fraction can be converted to a decimal fraction and then to a percent, a decimal fraction can be converted to a percent or to a common fraction, and a percent can be converted to a common or decimal fraction.

Converting Common Fractions to Decimals

Conversion of a common fraction to a decimal fraction is done by dividing the numerator of the fraction by the denominator. In this manner, the common fraction ¼ can be converted to the decimal fraction 0.25 ($\frac{1}{4} = 1 \div 4 = 0.25$).

Converting Decimals to Percents

A decimal fraction can be changed to a percent by moving the decimal point two places to the right in the figure and adding the percent sign (for example, 0.25 = 25%).

Converting Percents to Decimals

A percent fraction can be converted to a decimal by reversing the process used to convert a decimal to a percent. The percent sign is dropped, and the decimal point is then moved two places to the left (for example, 36% = 0.36).

Converting Common Fractions to Percents

In the conversion of a common fraction to a percent, the common fraction is converted to a decimal, and then the decimal is converted to a percent.

Converting Decimals to Common Fractions

To convert a decimal fraction to a common fraction, first write the figures given to the right of the decimal point as the numerator over a denominator made up of the numeral 1 followed by as many ciphers (zeros) as there are figures to the right of the decimal point. If 0.125 is to be converted to a common fraction, the figure 125 should be used as the numerator over the denominator 1,000 (the numeral 1 followed by a zero for every number to the right of the decimal point in the given decimal fraction). The resulting common fraction ($^{125}/_{1000}$) should then be reduced to lowest terms ($^{125}/_{1000} = {}^{1}/_{8}$). This system of converting decimals to common fractions is not entirely satisfactory for carpenters, however. Because the measurements they use are in eighths, sixteenths, or perhaps thirty-seconds of an inch and because the smallest division on the tape and square is generally $^{1}/_{16}$ inch, use of the method described above may result in common fractions with denominators that are not practical for carpenters (for example, $0.675 = {}^{675}/_{1000} = {}^{27}/_{40}$).

To determine the equivalent of a decimal fraction to the nearest sixteenth of an inch, multiply the decimal fraction by 16, and place this product as a numerator over 16 as the denominator. Then reduce this fraction to lowest terms. In the conversion of 0.375 to a common fraction equivalent in sixteenths, 0.375 is multiplied by 16 ($0.375 \times 16 = 6.000$), the product 6 is placed over 16 ($^6/_{16}$), and the fraction is reduced to lowest terms ($^6/_{16} = {}^3/_8$). The same procedure can be used to determine common fraction equivalents in eighths or thirty-seconds.

Converting Percents to Common Fractions

A percent can be converted to a common fraction by first converting the percent to a decimal and then converting the decimal to a common fraction.

MATHEMATICS

TOPIC 7 — DECIMAL AND FRACTIONAL EQUIVALENTS

Study Guide

Determine the correct answer for each of the following problems, and enter the result in the blank provided.

Express the following percents as decimal fractions:

1. 10 percent = __________
2. 25 percent = __________
3. 75 percent = __________
4. 90 percent = __________

Express the following decimals as percents:

5. 0.05 = __________
6. 0.02 = __________
7. 0.33 = __________
8. 1.50 = __________
9. 0.18 = __________

Express the following common fractions as decimals:

10. $\frac{1}{20}$ = __________
11. $\frac{7}{8}$ = __________
12. $\frac{7}{10}$ = __________
13. $\frac{1}{25}$ = __________

Express the following decimals as common fractions:

14. 0.75 = __________
15. 0.333 = __________
16. 0.10 = __________
17. 0.02 = __________

Express the following percents as common fractions:

18. 20 percent = __________
19. 2 percent = __________
20. 98 percent = __________
21. 52 percent = __________

Express the following common fractions as percents:

22. $\frac{1}{10}$ = __________
23. $\frac{1}{25}$ = __________
24. $\frac{3}{50}$ = __________
25. $\frac{5}{6}$ = __________

TOPIC 8 – PERIMETERS, AREAS, AND VOLUMES

This topic is planned to help you answer the following questions:

- **What types of measurement do carpenters use?**
- **What is meant by perimeter, area, and volume?**
- **What formulas are used in determining perimeter, area, and volume?**

The work of carpenters requires that they know how to determine not only the linear dimensions of surfaces with which they work but also their perimeters, areas, and volumes. Some common rules (formulas) for determining these and other measurements for various figures are shown in Table 8-1.

The term ***linear measure*** refers to the measurement of the length of a straight line that lies between two points, lines, or surfaces. In the carpentry trade, linear measure is usually expressed in inches, feet, or yards.

Determination of Perimeters

The distance around the outside limits (periphery) of a surface or object is called the ***perimeter*** of that surface or object. As it relates to circles, the perimeter is called the ***circumference***.

Circumference of a Circle

A circle is a plane figure bounded by a single curved line, each part of which is equally distant from the center point. The circumference (C) of a circle has already been identified as the distance around the circle. The ***diameter*** of a circle is a straight line connecting any two points on the circumference and passing through the center of the circle. The ***radius*** is a straight line extending from the center of the circle to any point on the circumference and is always equal to one-half the diameter. (See Fig. 8-1.) All radii of a given circle are equal in length.

A constant mathematical relationship exists between the circumference of a circle and its diameter: the circumference is always 3.1416 times as large as the diameter. This mathematical constant, expressed as π (the Greek letter *pi*), can be stated also as the improper fraction $^{22}/_{7}$. The measurements determined by using the decimal fraction, however, are more accurate than those computed using the common fraction.

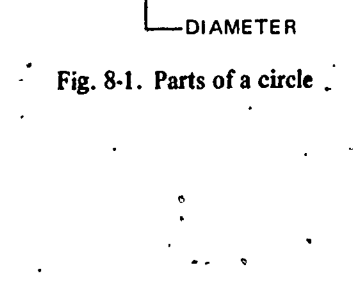


Fig. 8-1. Parts of a circle

To determine the circumference of a circle, you must know either the diameter or the radius. When the diameter is known, the circumference can be computed by using the following rule: circumference = $\pi \times$ diameter ($C = \pi \times D$). Therefore, the circumference of a circle having a diameter of 5 inches is 15.7080 inches (3.1416 × 5 in. = 15.7080 in.).

Since the radius of a circle is equal to one-half the diameter, the formula $C = 2R \times \pi$ can be used to find the circumference when only the radius is known. The circumference of a circle whose radius is 20 feet, for example, is determined to be 125.6640 feet (2 × 20 ft. = 40 ft., and 40 ft. × 3.1416 = 125.6640 ft.).

Perimeter of Other Closed Figures

The perimeter of other closed figures (square, rectangle, triangle, and so forth) can be determined by adding the dimensions of all sides of the figure.

The ability to determine the perimeter of an object, figure, or surface is essential to carpenters in estimating the amounts of materials needed for a job: the number of linear feet of form materials, cubic yards of concrete for the foundation, number of studs in the exterior walls, and so forth.

Determination of Areas

A plane surface has two dimensions—length and width. This surface measure, or ***area*** measure, is expressed in square units. The width and the length of a surface must both be expressed in the same units before an area measurement can be determined. If the length is given in inches, the width must also be in inches, and the area will be expressed in square inches. Similarly, if the width is in feet, the length must be in feet, and the area will be expressed in square feet. The area will always be expressed in terms of the linear measurement used in determining the width and length.

Area of a Circle

To find the area of a circle, multiply the radius by itself, and then multiply the resulting product by 3.1416 (π). Any number that is multiplied by itself is said to be squared. The symbol for squaring a number is a 2 following the number and written slightly above it. If 10 is to be squared, it is written as 10^2, which represents 10 X 10.

The rule for finding the area of a circle, then, is: area = π X radius squared ($A = \pi \times R^2$). Through the use of this rule, the area of a circle whose radius is 20 feet is determined to be 1,256.64 square feet (20 ft. X 20 ft. = 400 sq. ft., and 3.1416 X 400 sq. ft. = 1,256.64 sq. ft.).

Area of a Rectangle

A rectangle is a plane figure having four sides. The opposite sides of a rectangle are parallel and equal in length, and all the angles are right angles (90°). The long side of a rectangle is called its length (L), and the short side is its width (W). (See Fig. 8-2A.)

The product of the length of any rectangle multiplied by its width is equal to the area of that rectangle. As a formula the relationship is expressed as follows: $A = L \times W$. The rectangle in Fig. 8-2A has a length of 14 inches and a width of 10 inches. The area of this rectangle is therefore 140 square inches (14 in. X 10 in. = 140 sq. in.).

Area of a Square

A plane four-sided figure with each side (S) the same length and each angle a right angle is a square. (See Fig. 8-2B.)

Because a square is a type of rectangle (and both are parallelograms), the area of a square can be computed using the formula for the area of a rectangle, $A = L \times W$. However, because all sides of a square are equal in length, the area of a square is more easily found by squaring a side; that is, by multiplying one side by itself. A second formula for determining the area of a square, then, is: $A = S^2$. The area of the square in Fig. 8-2B is 100 square inches (10 in. × 10 in. = 100 sq. in.).

Area of a Parallelogram

A parallelogram consists of four sides, the opposite of which are equal and parallel. Unlike the other four-sided figures discussed in this topic, a parallelogram has no right angles, and only its opposite angles are equal. The length of a parallelogram is commonly called the base (B), and its height is usually expressed as the altitude (A). (See Fig. 8-2C.)

A parallelogram can be thought of as a rectangle with a triangle removed from one end and added onto the other end. To compute the area of a parallelogram, multiply its length (base) by the height (altitude). The formula for this operation is expressed as: $A = B \times A$. The base of the parallelogram in Fig. 8-2C is 14 inches, and the altitude is 10 inches. Therefore, its area is 140 square inches (14 in. X 10 in. = 140 sq. in.).

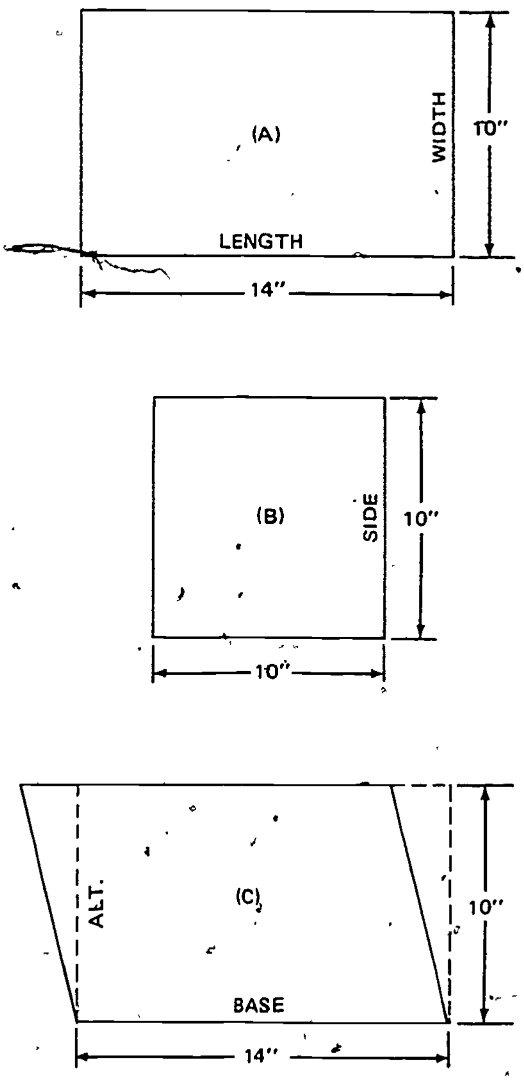


Fig. 8-2. Four-sided plane figures: (A) rectangle; (B) square; (C) parallelogram

Area of a Triangle

A triangle is a plane figure consisting of three line segments. Each of the line segments is a side of the triangle, and one of the sides is designated as the base. A triangle may have two or three equal sides, or none of its sides may be equal. A square-cornered triangle has one right angle and is therefore called a right triangle. (See Fig. 8-3A.) In an acute triangle each of the three angles is less than a right angle. (See Fig. 8-3B.) An obtuse triangle has one angle that is greater than a right angle. (See Fig. 8-3C.)

Any triangle is actually one-half of a rectangle (or one-half of a parallelogram in the case of an acute or obtuse triangle). This is clearly seen in Fig. 8-3A, where an identical but inverted right triangle is drawn above the shaded right triangle, making a rectangle. Similarly, "mirror image" triangles could be joined to the acute and obtuse angles in Figs. 8-3B and 8-3C to make parallelograms.

The area of a rectangle or a parallelogram is equal to its length (base) times its width (altitude). Because a rectangle or a parallelogram can be made by joining two identical triangles, it follows that the area of a triangle is equal to one-half the product of its base and its altitude. The rule is expressed in short form as $A = BA \div 2$. (BA is the same as $B \times A$.) The area of the right triangle in Fig. 8-3A is, therefore, 70 square inches (14 in. × 10 in. = 140 sq. in., and 140 sq. in. ÷ 2 = 70 sq. in.). By similar computation the area of the acute triangle in Fig. 8-3B is found to be 70 square inches, and the area of the obtuse triangle in Fig. 8-3C is 60 square inches.

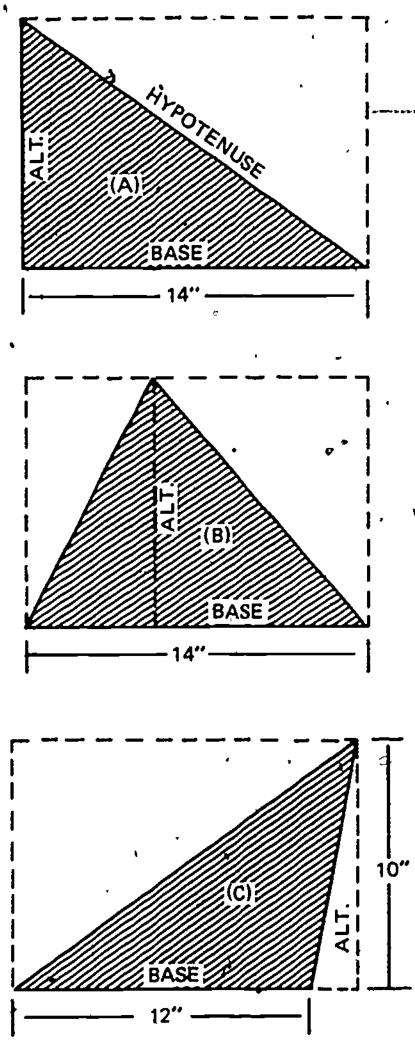


Fig. 8-3. Triangles: (A) right; (B) acute; (C) obtuse

Determination of Volume

The term ***volume*** can be defined as the cubic content of any solid that has length, width, and height. The volume of any solid is determined by cubic measure, and the unit of measure used is called a cube. (See Fig. 8-4.)

Volume of a Cube

A cube may be any length on a side (S) or edge (1 inch, 1 foot, 1 yard, and so forth); but each of the edges must be the same dimension. The opposite sides of a cube are also parallel, and all corners are square (90 degrees or right angles). The volume of a cube can be found by multiplying the length by the width by the height ($V = L \times W \times H$). However, since all edges of a cube are equal in length, finding the volume of a cube can be done by multiplying the length of an edge by itself and by itself again. This process of multiplying a number by itself and by itself again (4 × 4 × 4, for example) is called finding the cube of a number and can be expressed by writing a 3 to the right of and slightly above the number (for example, 4^3). The rule, then, for finding the volume of a cube can be expressed as $V = S^3$. The volume of the cube shown in Fig. 8-4 is, therefore, 8 cubic feet (2 ft. × 2 ft. × 2 ft. = 8 cu. ft.).

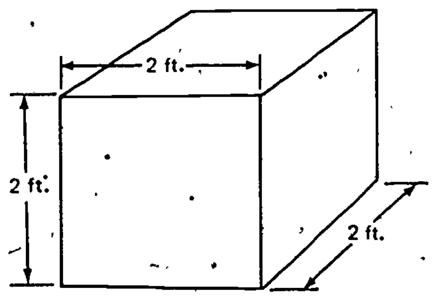


Fig. 8-4. A cube

Volume of a Rectangular Solid

A rectangular solid differs from a cube in that all sides or edges are not equal. (See Fig. 8-5.) The volume of a rectangular solid can be found only by multiplying the length by the width by the height (V = L X W X H). The volume of the rectangular solid shown in Fig. 8-5 is 24 cubic feet (4 ft. X 3 ft. X 2 ft. = 24 cu. ft.).

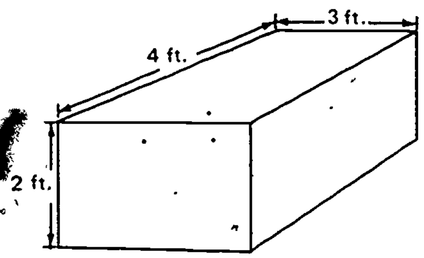


Fig. 8-5. A rectangular solid

Volume of a Cylinder

A cylinder is another shape that you may have to work with as a carpenter. A cylinder may have any length and any radius. (See Fig. 8-6.) Water pipes, gas pipes, and broom handles are examples of cylinders. The volume of a cylinder is found by multiplying the area of its base (a circle) by its height. This operation can be stated in the following rule: $V = \pi \times R^2 \times H$. The volume of the cylinder in Fig. 8-6 is 169.6464 cubic inches (3 in. X 3 in. = 9 sq. in.; 3.1416 X 9 sq. in. = 28.2744 sq. in.; and 28.2744 sq. in. X 6 in. = 169.6464 cu. in.).

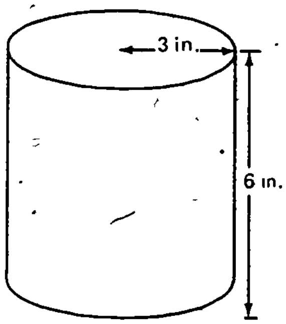


Fig. 8-6. A cylinder

TABLE 8-1

Common Rules for Mensuration

Area of a square	=	Length X width (height) Side squared
Area of a rectangle	=	Length X width (height)
Area of a triangle	=	Base X ½ altitude (height)
Area of a parallelogram	=	Base X altitude (height)
Area of a circle	=	Radius squared X 3.1416 (π) Diameter squared X 0.7854 ($\pi \div 4$)
Area of a sector of a circle	=	Length of arc X ½ radius
Area of the surface of a cylinder	=	Diameter of base X 3.1416 X height
Area of a cone	=	Radius X 3.1416 X slope length
Area of an ellipse	=	Product of the two diameters X 0.7854
Circumference of a circle	=	Diameter X 3.1416 Radius X 6.283185
Perimeter of a square, rectangle, triangle, parallelogram	=	Sum of all sides
Surface of a sphere	=	Diameter X circumference
Volume of a cube	=	Side cubed
Volume of a rectangular solid	=	Length X width X height
Volume of a cylinder	=	Radius of base squared X 3.1416 X height
Volume of a cone	=	Radius squared X 3.1416 X height X ⅓
Volume of a pyramid	=	Area of base X height X ⅓
Volume of a sphere	=	Diameter cubed X 0.5236

MATHEMATICS

TOPIC 8 — PERIMETERS, AREAS, AND VOLUMES

Study Guide

Determine the correct answer for each of the following problems, and enter the result in the corresponding blank at the right.

1. A house is 28 feet 6 inches wide and 35 feet 9 inches long. What is its perimeter? 1. ________
2. How many linear feet of crown molding will be required to do a rectangular living room measuring 16 feet 3 inches by 22 feet 9 inches? (Allow 4 ft. for waste.) 2. ________
3. How many linear feet of fence will be required to fence a playground that is square and that measures 76 feet 0 inches on each side? 3. ________
4. What is the area of a kitchen measuring 9 feet 3 inches by 16 feet 9 inches (no allowance for walls)? 4. ________
5. What is the area of a garage 19 feet 8 inches by 20 feet 0 inches? 5. ________
6. What is the area of a fireplace footing 3 feet 9 inches by 5 feet 0 inches? 6. ________
7. A room is 14 feet 0 inches by 18 feet 0 inches by 8 feet 0 inches. How many cubic feet does it contain? 7. ________
8. An excavation is to be 34 feet 0 inches long, 28 feet 0 inches wide, and 8 feet 0 inches deep. How many cubic yards of earth must be removed? 8. ________
9. How many cubic feet of concrete are contained in a sidewalk 3 feet 0 inches wide, 82 feet 0 inches long, and 4 inches thick? 9. ________
10. If the diameter of a circular table is 42 inches, what is the circumference of the table? 10. ________
11. A redwood batten ⅜ inch by 4 inches is to be used as a form around a circular flower bed 5 feet in diameter. How long must this batten be if made in one piece? 11. ________
12. How many cubic feet of concrete will be required to pour the curb of a circle with a radius of 42 feet if it takes ½ cubic foot of concrete per linear foot of curb form? 12. ________
13. What is the area of a circular patio with a diameter of 32 feet? 13. ________
14. Which has the greater area, a circle with a diameter of 8 inches or a square with 8-inch sides? 14. ________
15. A circular flower bed 14 feet in diameter has a 3-foot-wide concrete walk around it. If the price per square foot of concrete is $0.48, how much does the walk cost? 15. ________
16. How many cubic feet of concrete will be required to pour a cylindrical column 18 inches in diameter and 11 feet 0 inches high? 16. ________

17. How many cubic yards of dirt will be removed to excavate a circular pool 30 feet in diameter and 7 feet deep? 17. ________

18. The inside diameter of a circular water tank is 14 feet 8 inches, and the inside height is 34 feet 4 inches. How many gallons of water will the tank contain when filled? (One cubic foot contains 7½ gallons.) 18. ________

19. What is the volume in cubic feet of a cube with sides 1 yard in length? 19. ________

20. A circle has a radius of 12 inches. What is the area of the circle? 20. ________

MATHEMATICS

TOPIC 9 – SQUARES AND SQUARE ROOT

This topic is planned to help you answer the following questions:

- **What is an "exponent" in mathematics?**
- **What is the "power" in reference to mathematics?**
- **What is the square root of a number?**
- **Why must you know how to extract square roots in the carpentry trade?**

Definition of Terms

Some information about the square of a number was presented in Topic 8. You should remember, for example, that a number multiplied by itself is said to be squared. Recall also that an abbreviated way to express the squaring of a number is to write the number with a 2 to the right and slightly above it, such as 6^2 (six squared). The number used to indicate that a number is to be squared is called an exponent. An exponent actually indicates how many times a specific number is to be used as a factor in multiplication. The expression 8^2 indicates that 8 is to be used twice as a factor or that 8 is to be squared. The expression 8^3 means that 8 is to be used as a factor three times or that 8 is to be cubed ($8 \times 8 \times 8 = 512$). The product of this type of multiplication is called the power.

Finding the square root of a number may be desirable or necessary. The square root of a number is the number that when multiplied by itself equals the given number. The square root of 4 is readily seen to be 2 since, from knowledge of the simple multiplication tables, you know that $2 \times 2 = 4$. Square root is expressed using a radical sign: $\sqrt{}$. This sign written above any number indicates that the square root of the given number is to be extracted (found).

Extraction of Square Roots

Square roots of small numbers having roots that are whole numbers may be determined by estimation or by trial and error. However, the use of estimation or trial and error may not be feasible or possible with larger numbers. An arithmetical process exists for extracting square roots. Knowledge of this process can be very useful in the carpentry trade. Determining the length of the hypotenuse of a right triangle is an example of a calculation that involves extracting a square root. You can generally use a table of square roots or a calculator to solve such a problem, but in those cases in which square root tables or a calculator is not available, you should be prepared to extract the root arithmetically. In the following step-by-step example, the square root of 274,576 is extracted.

Step 1. Separate the number into groups of two numbers each, beginning at the right and working to the left. Place a curved line over each group of numbers. The number of groups thus formed will be the same as the number of whole numbers in the answer (root).

$$\overset{\frown}{27}\ \overset{\frown}{45}\ \overset{\frown}{76}$$

Step 2. Draw the radical sign over the number.

$$\sqrt{\overset{\frown}{27}\ \overset{\frown}{45}\ \overset{\frown}{76}}$$

Step 3. Look at the number in the first grouping to the left, and determine what number multiplied by itself (squared) will equal or most nearly equal it without exceeding it. In this case the number to be considered is 27. Since $6 \times 6 = 36$, the number 6 is obviously too large. The next smaller number is 5, and $5 \times 5 = 25$. The product 25 is smaller than 27, so 5 is the number to be used. Write 5 above the 27, and place 25 (the product of 5×5) below the 27. Then subtract 25 from 27, and write the remainder (2).

$$\begin{array}{l} \quad 5 \\ \sqrt{\overset{\frown}{27}\ \overset{\frown}{45}\ \overset{\frown}{76}} \\ \underline{\ 25\ } \\ \quad 2 \end{array}$$

Step 4. Bring down the next group of numbers, placing it beside the remainder 2. This gives 245.

```
   5
 √27 45 76
  25
   2 45
```

Step 5. Draw a line down from the radical sign. Multiply the first figure of the root by 2 (2 X 5 = 10 in this case), and place the product (10) to the left of the 245 and to the left of the line. This 10 is called the trial divisor.

```
      5
    √27 45 76
   | 25
10 |  2 45
```

Step 6. Determine how many times 10 is contained in 24, the first *two* figures in 245. The number 10 is contained two times in 24. This 2, then, is determined to be the second number of the root. Place 2 above the second group of numbers (above the number to the extreme right in the group) and also to the right of the trial divisor (to the right of the 10 in this case). Then multiply the trial divisor (102) by the second number (2) in the root (102 X 2 = 204). Place the product (204) under the 245, and subtract. The remainder is 41.

```
       5  2
    √27 45 76
    | 25
102 |  2 45
    |  2 04
    |    41
```

Step 7. Bring down the next group of numbers (76), placing it next to the 41. Multiply the root number 52 by 2, and place the product to the left of the line and in line with 4,176. Now determine how many times 104 is contained in 417, the first *three* numbers in 4,176. The number 104 is contained four times in 417. Write 4 in the root line and in the trial divisor. Multiply 1,044 (the new trial divisor) by 4 (the new number in the root line). Write the product of this multiplication (1,044 X 4 = 4,176) under 4,176, and subtract. Since there is no remainder (4,176 − 4,176 = 0), the square root of 274,576 is 524. To check the accuracy of the answer, square the root number (524^2 = 524 X 524 = 274,576). The square of the root number should equal the number for which the square root was desired; that is, the number under the radical sign.

```
        5  2  4
     √27 45 76
     | 25
102  |  2 45
     |  2 04
1044 |    41 76
     |    41 76
     |    00 00
```

If a decimal point appears in a number for which the square root is to be found, the numbers must be divided into groups both to the right and left of the decimal point. Zeros must be added to the right of the decimal point either singly or in pairs as needed to maintain groups of two numbers to the right of the decimal point. An operation to extract the square root of 5 to two decimal places, for example, can be indicated in this manner: $\sqrt{5.00\ 00}$. Note that the decimal point should be placed in the root line directly above the decimal point in the number under the radical sign.

In the case of extracting the square root of a number with an odd number of figures to the left of the decimal point, the last grouping to the left will contain a single number only. The number 144 is an example of such a number. Written under the radical sign, 144 is indicated as $\sqrt{1\ 44}$. In the extraction of the square root of 144, treat the 1 the same as any two-digit grouping.

Study Guide

Determine the correct answer for each of the following problems, and enter the result in the blank provided. In rewriting and solving problems, be careful to align numbers correctly.

1. $\sqrt{625}$ = __________
2. $\sqrt{256}$ = __________
3. $\sqrt{2,116}$ = __________
4. $\sqrt{60,516}$ = __________
5. $\sqrt{10.5625}$ = __________
6. $\sqrt{3}$ (carried out to two decimal places) = __________
7. $\sqrt{2}$ (carried out to three decimal places) = __________
8. $\sqrt{1.6}$ (carried out to two decimal places) = __________
9. $\sqrt{25,375}$ (carried out to two decimal places) = __________
10. $\sqrt{496.5}$ = __________

MATHEMATICS

TOPIC 10 – THE RIGHT TRIANGLE

This topic is planned to help you answer the following questions:

- **How is the carpenter's framing square used in solving layout problems?**
- **Why is an understanding of the right triangle important in carpentry?**
- **How can you lay out right angles beyond the capacity of the carpenter's square?**
- **Why must you know how to calculate the length of the hypotenuse of right triangles?**

Use of the Carpenter's Square

The use of the carpenter's framing square in solving layout problems in construction is based on certain characteristics of the right triangle. However, a discussion of the right triangle requires an understanding of terms used and geometrical principles involved.

Where a vertical line and a horizontal line meet, the two angles formed are equal and are 90 degrees (90°). The two lines are said to be ***perpendicular*** to each other, and the sum of the two equal angles formed where the lines meet is 180 degrees. Each of these 90-degree angles is called a ***right angle***. A triangle (a three-sided figure) may have only one right angle, and the sum of the other two angles is always 90 degrees. The side opposite the right angle is called the ***hypotenuse***.

Layout Problems

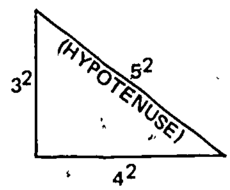
After you become familiar with the carpenter's tape and square and with the characteristics of the right triangle, you will be able to perform the following layout tasks:

1. Layout of an exact 90-degree angle without using instruments other than a measuring tape
2. Determination of the length of the hypotenuse of a right triangle when the lengths of the two adjacent sides are known (line length of a rafter from rise and run, for example)
3. Determination of the length of the hypotenuse of a right triangle using the "step" or "unit" system
4. Determination of the area of any triangle when the base and altitude (height) are known

Angles of 90 degrees with short sides may be laid out directly with a framing square. However, right angles with sides longer than can be measured with the carpenter's framing square may be laid out accurately by applying the Pythagorean Theorem, which is a statement of one of the principles of a right triangle: *The square of the hypotenuse is equal to the sum of the squares of the other two sides.*

A triangle having sides of 3, 4, and 5 units will contain one 90-degree angle. Note that this is the smallest combination of whole numbers that fulfills the requirements of the Pythagorean Theorem—$3^2 + 4^2 = 5^2$. (See Fig. 10-1.)

The layout of a square corner for a large building can be done more accurately using a larger but similar triangle. The basic 3-4-5 pattern may be multiplied by any factor, such as 2 to obtain 6-8-10, to produce a combination of numbers that will fulfill the requirements of the Pythagorean Theorem. Any desired or required increase in size may be accomplished by multiplying these basic numbers by the same factor.



3 x 3 = 9
4 x 4 = 16
25

5 x 5 = 25

Fig. 10-1. Illustration of the Pythagorean Theorem

Determination of Hypotenuse Length

Calculating the length of the hypotenuse (or diagonal) is necessary for determining the length of braces, stair stringers, and rafters of various types. When the vertical and horizontal sides of a right triangle are known (total rise and total run of a rafter), the hypotenuse (rafter length) can be determined by extracting the square root of the sum of the squares of the two sides adjacent to the right angle. For example, if the total rise of a rafter is 5 feet and the total run is 12 feet, the rafter length (hypotenuse) is determined to be 13 feet ($5^2 + 12^2 = 25 + 144 = 169$, and $\sqrt{169} = 13$).

The diagonal of a triangle with two sides equal in length or the diagonal of a square can be found by multiplying the length of a side by 1.414. (See Fig. 10-2.)

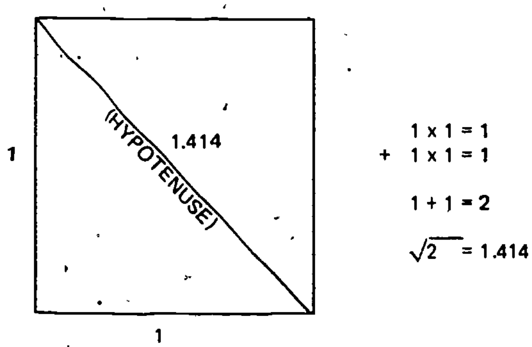


Fig. 10-2. Determining the hypotenuse of a right triangle with two equal sides (diagonal of a square)

The carpenter's framing square can be used in two ways to determine the length of the hypotenuse of a right triangle (with two equal sides) without extracting the square root:

1. The diagonal of a right triangle can be determined using the inches and twelfths scale on the outer edge of the back of the square, by letting 1 inch equal 1 foot; $^1/_{12}$ inch would then equal 1 inch. By accurately measuring the diagonal, you can attain enough accuracy for most construction.
2. The units can be stepped off with a framing square. (See Fig. 10-3.) This is a very common method. A basic requirement of this method of layout is that each of the three sides have the same number of steps.

The areas of gable ends, triangular-shaped sections of hip roofs, and plots of land may be determined when certain necessary dimensions are known. The area of any triangle is determined by using the following formula: area equals base times altitude divided by two, or A = BA ÷ 2. (See Fig. 10-4.)

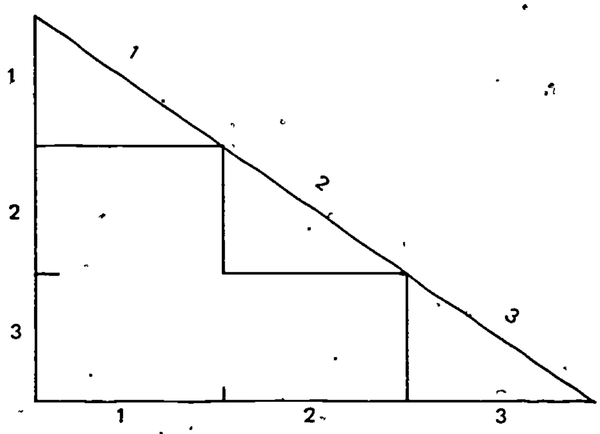


Fig. 10-3. Stepping off units with a framing square

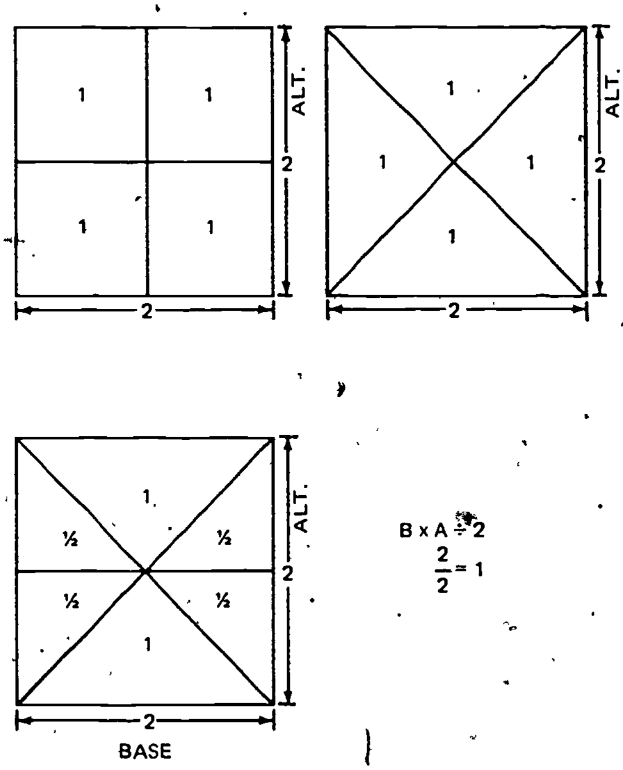


Fig. 10-4. Illustration of the area of a triangle

MATHEMATICS

TOPIC 10 – THE RIGHT TRIANGLE

Study Guide

Determine the correct answer for each of the following problems, and enter the result in the blank provided.

Supply the dimension required in the following groups of figures to make each group the dimensions of a right triangle:

1. 3 __ 5 (hypotenuse)
2. __ 12 15 (hypotenuse)
3. 18 24 __(hypotenuse)
4. 5 12 __(hypotenuse)

Find the hypotenuse of right triangles with the following dimensions, using the arithmetical method.

5. Base 8 feet 0 inches and altitude 6 feet 0 inches = __________
6. Base 16 feet 0 inches and altitude 12 feet 0 inches = __________
7. Base 10 feet 0 inches and altitude 6 feet 8 inches = __________
8. Base 13 feet 0 inches and altitude 21 feet 6 inches = __________

Use a framing square to determine the diagonals of right triangles with the following bases and altitudes:

9. 10 inches x 15 inches = __________
10. 1 foot 6 inches x 18 feet 0 inches = __________
11. 8 feet 0 inches x 20 feet 6 inches = __________
12. 10 feet 5 inches x 14 feet 5 inches = __________

Find the areas of triangles with the following dimensions:

13. Base 8 feet 0 inches and altitude 6 feet 0 inches = __________
14. Base 10 feet 9 inches and altitude 7 feet 3 inches = __________
15. Base 9 feet 6 inches and altitude 3 feet 4 inches = __________
16. Base 12 feet 8 inches and altitude 4 feet 4 inches = __________
17. Base 13 feet 2 inches and altitude 6 feet 5 inches = __________
18. Base 29 feet 0 inches and altitude 12 feet 6 inches = __________
19. Base 18 feet 4 inches and altitude 13 feet 6 inches = __________
20. Base 22 feet 6 inches and altitude 16 feet 4 inches = __________

TOPIC 11 – LUMBER PRODUCTS AND BOARD MEASURE

This topic is planned to help you answer the following questions:

- **How are standards for lumber and lumber products set and maintained?**
- **What are the various factors to be considered in grading lumber?**
- **How should a purchase order for lumber be made out?**
- **What is the sale of lumber based on?**
- **How can a framing square be used in calculating the board feet in a piece of lumber?**

Definition of Lumber

The term *lumber* as used in the carpentry trade refers to the manufactured product and not to the tree in its natural state. The lumber-manufacturing industry, like most other industries, is in a constant state of change. Lumber-manufacturing and marketing methods are continually being improved.

Lumber Standards

Standardization in the lumber-manufacturing industry is for the protection of the consumer and for convenience of communication within the industry. Specifications and grades of lumber are standardized by regulations of the American Lumber Standards and by trade associations, such as Western Wood Products Association and the American Plywood Association. These associations set standards that individual mills must meet to qualify for and to maintain their membership in the associations.

Factors in Grading

The factors that are considered in grading lumber are many and complex. They include species of lumber; size; grain; size and spacing of imperfections; surface texture; profile; moisture content; and so forth. Framing lumber may be "visually graded" or "machine stress" graded. Regardless of the method used, each piece of lumber is marked with a grade stamp. Also, the industry is developing a process of stamping each piece of framing lumber with span symbols. These symbols, referenced to simplified span tables, will indicate the maximum allowable spans that can be made in fabricating joists and rafters.

Purchase Orders

During your apprenticeship you should learn to make out a purchase order for lumber in accordance with the practices utilized in your own marketing area. The information in a purchase order usually includes size, species, classification, surface texture, grade, number of pieces, and length of each piece, as in the following examples:

2 x 8 Douglas fir, Joists, S4S, Standard and better, 48 pieces, 16 feet long

2 x 12 Redwood, Rough, Construction, 15/12, 20/16, 25/14 (15 twelves, 20 sixteens, 25 fourteens)

The finished size, or dressed size, of lumber is very important in detailing and in actual dimensions in construction. However, the sale of lumber is based on the rough, or "nominal," size (2 x 4, 1 x 6, 2 x 8, 3 x 12, and so forth). This nominal size is used in calculating the number of board feet contained in a piece of lumber. The price is stated as so much per board foot or so much per 1,000 board feet (Mb.f.). Lumber less than 1 inch in thickness is figured as 1 inch.

Calculation of Board Feet

The term *board measure* implies that the unit of measure for lumber is the board foot. A board foot is 1 inch thick, 12 inches wide, and 1 foot long (or any combination of factors that will give the same result). For example, 1 inch X 12 inches X 1 foot = 1 b.f., or stated as a true equation, 1 inch X $\frac{12}{12}$ inch X 1 foot = 1 b.f. The formula for calculating board feet can be stated as follows:

$$\frac{\text{Pieces} \times \text{Thickness (in.)} \times \text{Width (in.)} \times \text{length (ft.)}}{12}$$

Through the use of this formula, an order for 15 pieces of 2 x 8 each 18 feet long would be figured as follows: 15 X 2 X 8 X 18 ÷ 12 = 360 b.f. (4,320 ÷ 12 = 360).

The cancellation method used with the formula is the fastest and most practical method for you to use in the field. However, for use with an office machine, a table of constants may be worked out and used to advantage under some conditions. The carpenter's framing square has imprinted upon it an "Essex Board Measure," which can be used in calculating the number of board feet in a piece of lumber.

MATHEMATICS

TOPIC 11 – LUMBER PRODUCTS AND BOARD MEASURE

Study Guide

Determine the correct answer for each of the following problems, and enter the result in the corresponding blank at the right.

1. The number of board feet contained in 24 pieces 2 inches x 10 inches x 16 feet = 1. ________
2. The number of board feet contained in 18 pieces 1 inch x 8 inches x 14 feet = 2. ________
3. The number of board feet contained in 23 pieces 1 inch x 4 inches x 14 feet = 3. ________
4. The number of board feet contained in 15 pieces 4 inches x 4 inches x 18 feet = 4. ________
5. The number of board feet contained in 45 pieces 1 inch x 6 inches x 16 feet = 5. ________
6. The number of board feet contained in 12 pieces 2 inches x 8 inches x 18 feet = 6. ________
7. The number of board feet contained in 9 pieces 4 inches x 12 inches x 20 feet = 7. ________
8. The number of board feet contained in 17 pieces 2 inches x 6 inches x 14 feet = 8. ________
9. What is the total board feet in problems 1 through 8? 9. ________
10. If a quoted price is $112 per M, what would be the total cost of the lumber involved in problems 1 through 8? 10. ________

TOPIC 12 – METRIC MEASUREMENTS AND CONVERSION

This topic is planned to help you answer the following questions:

- **What number is the metric system of measurement based on?**
- **How can the English system and the metric system be used at the same time?**
- **How are conversions made from one system to the other?**

Two standards of measurement are being used in the world—the British imperial system (English system) and the metric system. The English system is used widely in the United States and Great Britain, and the metric system is used throughout Europe and to some extent in the United States.

The English system is based on the yard (36 inches), and the metric system is based on the metre (39.37 inches). The metric system is a decimal system, similar to the U.S. monetary system. All units in the metric system are based on the metre, which is divided into decimetres (tenths), centimetres (hundredths), and millimetres (thousandths). One metre, then, contains 10 decimetres, 100 centimetres, and 1 000 millimetres. Ten metres equals a decametre, 100 metres is a hectometre, and 1 000 metres is equal to a kilometre. The metric system obviously is much easier to use than the English system, in which the inch may be divided into halves, fourths, eighths, and so forth.

Apprentices and journey-level carpenters would do well to learn as much as possible about the metric system, for in the near future it will become the standard system of measurement in the United States. Naturally, the changeover from the English to the metric system will cause some difficulty for all workers because the units of one system are not evenly divisible by the units of the other. (See Figs. 12-1 and 12-2.) But this period of difficulty should exist only until one is able to think entirely in terms of the metric system; that is, until one no longer feels the need to "translate" a given metric quantity into its corresponding form in the English system. One of the principal benefits to be gained from utilization of the metric system is that the use of metric units will eventually eliminate the complications involved in calculating with common fractions. During the changeover period, perhaps the easiest and surest way of working with metric units is to use conversion tables such as those provided in tables 12-1 and 12-2.

Conversion of Metric Units to English Units

To convert metric units to English units, multiply the given number of metric units by the corresponding factor for that unit shown in Table 12-1, and round off the resulting product to the number of decimal digits needed for practical application. For example, to convert 200 millimetres to inches, multiply 200 by 0.03937, the number of inches contained in 1 millimetre. Then round off the answer to the desired number of decimal places (200 × 0.03937 in. = 7.87400 in. = 7.87 in.). If a common fraction is more desirable or practical in the answer than a decimal fraction, convert the decimal to the *nearest* common fraction (7.87 in. = 7⅞ in.).

Conversion of English Units to Metric Units

The first step in converting English units to metric units is to change any fractional part of the English unit to its equivalent decimal form. Then multiply the given quantity of English units by the corresponding factor for that unit shown in Table 12-2, and round off the result to the precision required. In the conversion of 1,531¼ square feet to square metres, for example, the number of square feet should be restated with the common fraction expressed as a decimal (1,531¼ = 1,531.25). The number of square feet is then multiplied by 0.0929, the number of square feet in a square metre (1,531.25 × 0.0929 m² [square metres] = 142.253125 m²); and the product is rounded off to the desired number of decimal places (142.253125 m² = 142.25 m²). *NOTE:* Relatively small measurements, such as 17.3 centimetres, are generally expressed in equivalent millimetre form (17.3 centimetres would be expressed as 173 millimetres).

You should be aware that the conversion of measurements from one system to the other will produce only semiaccurate equivalents. Complete accuracy cannot be attained, because the units of one system are not evenly divisible by the units of the other, as mentioned previously. However, increasing the number of decimal places to which the metric unit is carried out increases the accuracy of the conversion. As an example of this accuracy problem in conversion, consider that a 4- by 8-foot sheet of plywood would be determined to be 1.2191 metres

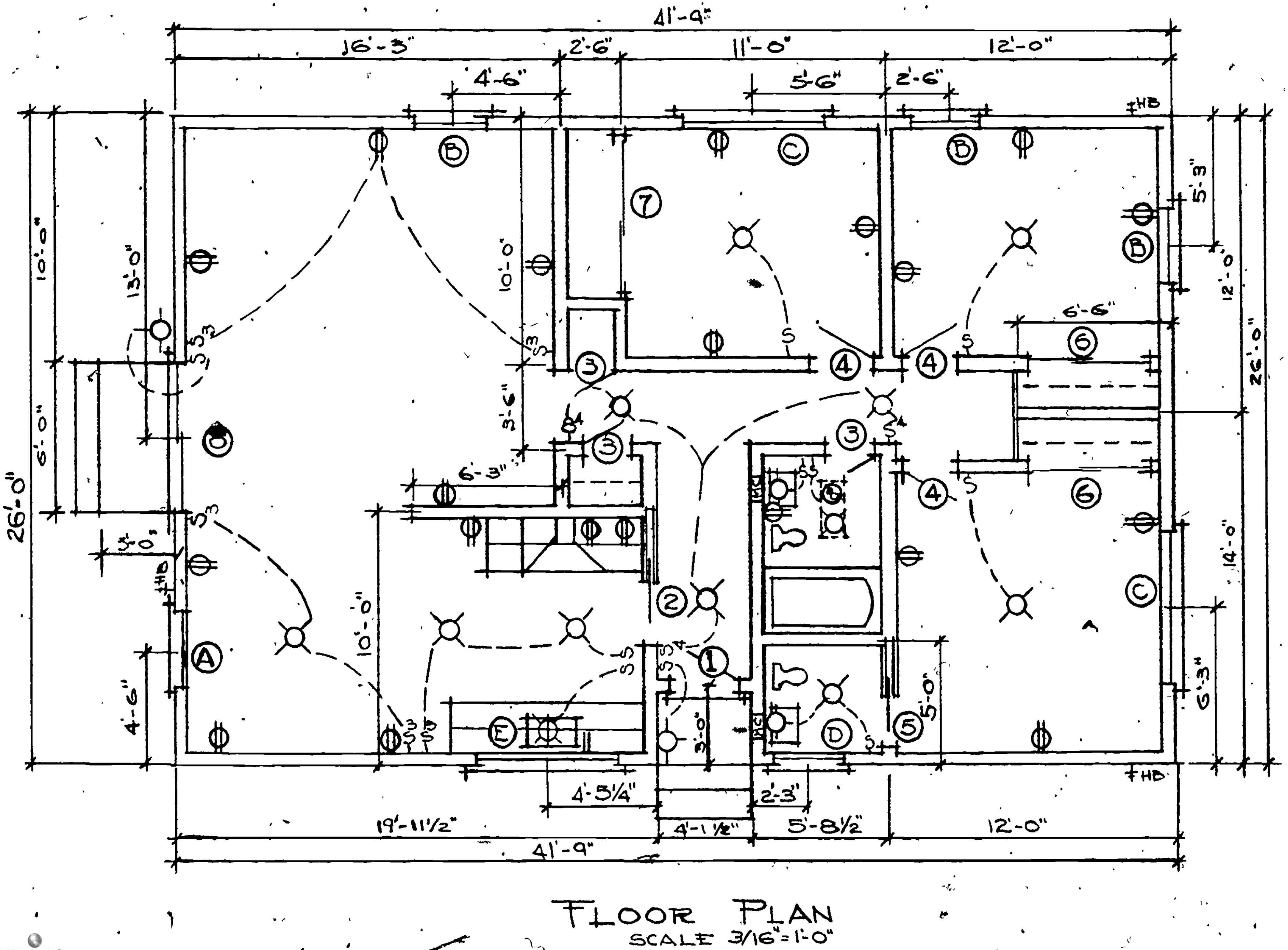


Fig. 12-1. Floor plan expressed in feet and inches

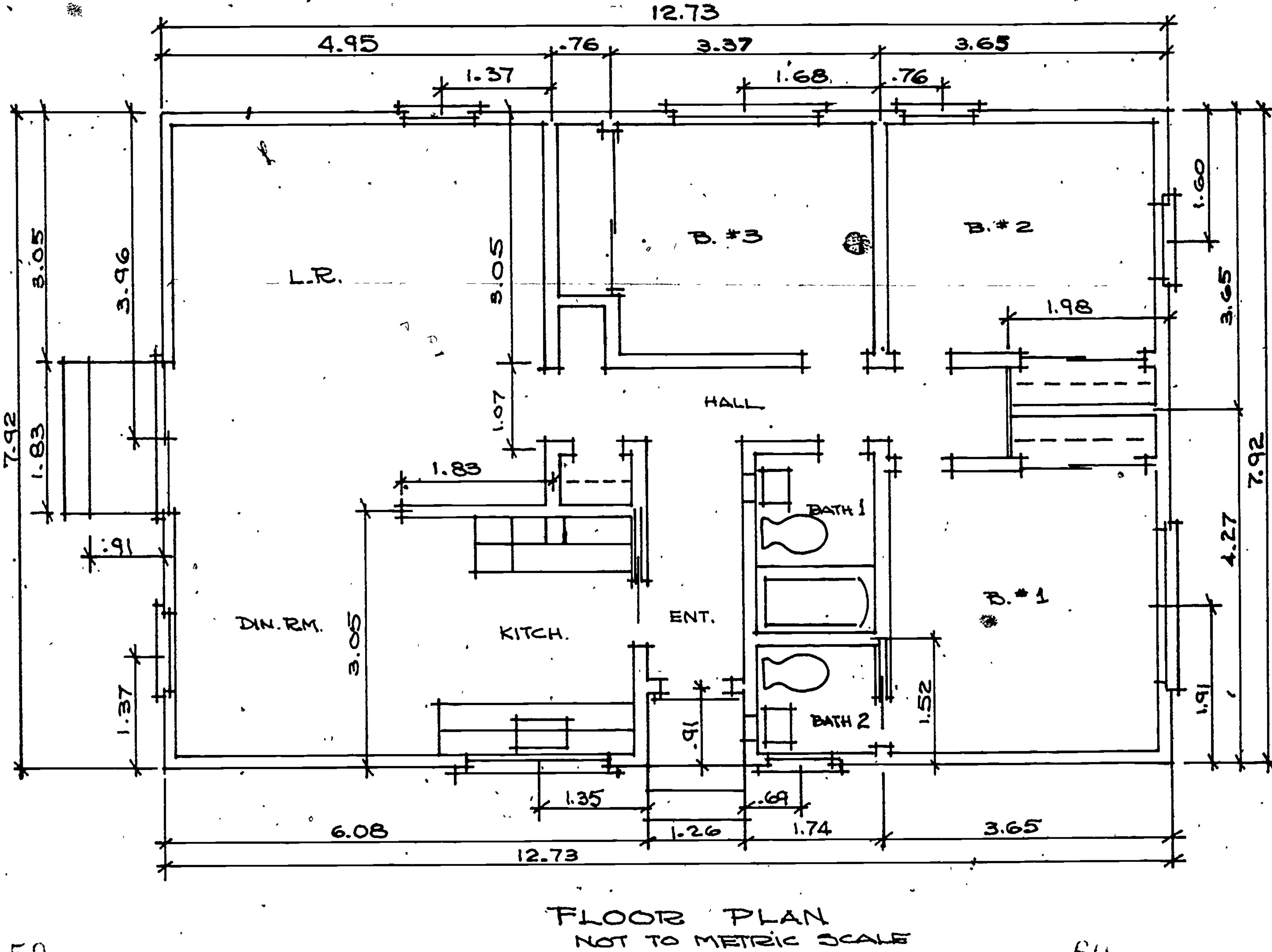


Fig. 12-2. Floor plan expressed in metres

by 2.4384 metres. For practical purposes this dimension would be easier to work with if the metric units were rounded off to two decimal places; that is, to 1.22 metres by 2.44 metres. These dimensions could be rounded off to even dimensions (1 metre to 2 metres); but use of these figures would then alter the spacing to be used between floor joists, studs, ceiling joists, roof rafters, and so forth.

TABLE 12-1

Conversion Factors for Metric to English Units

Type of measure	To change from	To	Multiply by
Linear	Millimetres (mm)	Inches	0.03937
	Centimetres (cm)	Inches	0.3937
	Centimetres (cm)	Feet	0.03281
	Decimetres (dm)	Inches	3.937
	Decimetres (dm)	Feet	0.3281
	Metres (m)	Inches	39.37
	Metres (m)	Feet	3.28083
	Metres (m)	Yards	1.0936
	Decametres (dkm)	Feet	32.80
	Hectometres (hm)	Feet	328.0
	Kilometres (k)	Miles	0.6241
Area	Square millimetres (m^2)	Square inches	0.00155
	Square centimetres (cm^2)	Square inches	0.1550
	Square decimetres (dm^2)	Square inches	15.50
	Square decimetres (dm^2)	Square feet	0.1076
	Square metres (m^2)	Square inches	1550.0
	Square metres (m^2)	Square feet	10.76
	Square metres (m^2)	Square yards	1.196
Volume	Cubic centimetres (cm^3)	Cubic inches	0.06102
	Cubic decimetres (dm^3)	Cubic inches	61.023
	Cubic metres (m^3)	Cubic feet	35.315
	Cubic metres (m^3)	Cubic yards	1.308
Weight	Grams (g)	Ounces (avoir.)	0.03527
	Grams (g)	Pounds	0.002205
	Kilograms (kg)	Pounds	2.205
	Metric tons (MT)	Pounds	2205.0
Power	Kilowatts (kw)	Horsepower	1.34
	British thermal units (Btu)	Calories	252.0
Temperature	Centigrade (C)	Fahrenheit	Use the formula: $F^\circ = (C^\circ \times 9/5) + 32$

TABLE 12-2

Conversion Factors for English to Metric Units

Type of measure	To change from	To	Multiply by
Linear	Inches (in)	Millimetres	25.4
	Inches (in)	Centimetres	2.54
	Inches (in)	Decimetres	0.254
	Feet (ft)	Centimetres	30.48
	Feet (ft)	Decimetres	3.048
	Feet (ft)	Metres	0.3048
	Yards (yd)	Centimetres	91.44
	Yards (yd)	Metres	0.9144
	Miles (mi)	Kilometres	1.609
Area	Square inches (sq in)	Square centimetres	6.451
	Square inches (sq in)	Square decimetres	0.0645
	Square feet (sq ft)	Square centimetres	929.0
	Square feet (sq ft)	Square decimetres	9.29
	Square feet (sq ft)	Square metres	0.0929
	Square yards (sq yd)	Square metres	0.8361
	Square miles (sq mi)	Square kilometres	2.590
Volume	Cubic inches (cu in)	Cubic centimetres	16.387
	Cubic feet (cu ft)	Cubic metres	0.0283
	Cubic yards (cu yd)	Cubic metres	0.7646
Weight	Ounces-avoir. (oz)	Grams	28.35
	Pounds (lb)	Grams	453.6
	Pounds (lb)	Kilograms	0.454
Liquid	Ounces (oz)	Litres	0.02957
	Fluid ounces (fl oz)	Cubic centimetres	29.574
	Pints (pt)	Litres	0.473
	Quarts (qt)	Litres	0.9464
	Gallons (gal)	Litres	3.785
Power	Horsepower (hp)	Kilowatts	0.746
	Calories (cal)	British thermal units	0.003968
Temperature	Fahrenheit (F)	Centigrade	Use the formula: $C° = (F° - 32) \times 5/9$

MATHEMATICS

TOPIC 12 – METRIC MEASUREMENTS AND CONVERSION

Study Guide

Determine the correct answer for each of the following problems, and enter the result in the corresponding blank at the right.

1. The metric system is based on the number _1_. 1. ________
2. The letters *mm* are the abbreviation for _2_. 2. ________
3. The letters *cm* are the abbreviation for _3_. 3. ________
4. The letters *km* are the abbreviation for _4_. 4. ________
5. In liquid measure, 1 quart is equal to 0.9463 _5_. 5. ________
6. One square foot is equal to _6_ square centimetres. 6. ________
7. Working with two systems of measurement will create a situation that requires _7_ from one to the other. 7. ________
8. The equivalent of 9963.25 millimetres is _8_ feet and _9_ inches. 8. ________
9. A wall is 75 feet $4^{13}/_{16}$ inches long. Its length in millimetres is _10_. 9. ________
10. The basic unit of measure in the metric system is the _11_. 10. ________
11. The equivalent of 25 square metres is _12_ square feet. 11. ________
12. A foundation wall form contains 1,728 cubic inches per running foot. If the form is 27 feet long, _13_ cubic yards of concrete must be ordered to fill it. 12. ________
13. A wall that is 63 millimetres wide, 75 millimetres high, and 3400 metres long contains _14_ cubic metres of concrete. 13. ________
14. The number of square feet contained in the building represented in Fig. 12-1 is _15_. 14. ________
15. The number of square metres contained in the building represented in Fig. 12-2 is _16_. 15. ________

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Instructional Materials

Materials Required for Each Apprentice*

California Contemporary House Plans. Sacramento: California State Department of Education, 1975. (Orders to: California State Department of Education, Publications Sales, P.O. Box 271, Sacramento, CA 95802.)

CAL/OSHA, State of California Construction Safety Orders (Current edition). Los Angeles: Building News, Inc. (Orders to: Building News, Inc., 3055 Overland Ave., Los Angeles, CA 90034.)

Durbahn, Walter E., and Robert E. Putnam. *Fundamentals of Carpentry*, Vol. 1, *Tools, Materials, and Practices* (Fifth edition). Chicago: American Technical Society, 1977. (Orders to: American Technical Publishers, 12235 S. Laramie Ave., Alsip, IL 60658.)

Durbahn, Walter E., and Elmer W. Sundberg. *Fundamentals of Carpentry*, Vol. 2, *Practical Construction* (Fifth edition). Chicago: American Technical Society, 1977. (Orders to: American Technical Publishers, 12235 S. Laramie Ave., Alsip, IL 60658.)

Dwelling Construction Under the Uniform Building Code (1979 edition). Whittier, Calif.: International Conference of Building Officials. (Orders to: International Conference of Building Officials, 5360 S. Workman Mill Rd., Whittier, CA 90601.)

Materials Recommended for Further Reference

Feirer, John L., and Gilbert R. Hutchings. *Carpentry and Building Construction*. New York: Charles Scribner's Sons, 1977. (Orders to: Charles Scribner's Sons, 597 Fifth Ave., New York, NY 10017.)

Sundberg, Elmer W. *Building Trades Blueprint Reading:* Part 1—*Fundamentals* (Fifth edition revised). Chicago: American Technical Society, 1972. (Orders to: American Technical Publishers, 12235 S. Laramie Ave., Alsip, IL 60658.)

Sundberg, Elmer W. *Building Trades Blueprint Reading:* Part 2—*Residential and Light Commercial Construction* (Second edition). Chicago: American Technical Society, 1974. (Orders to: American Technical Publishers, 12235 S. Laramie Ave., Alsip, IL 60658.)

Uniform Building Code (1979 edition). Whittier, Calif.: International Conference of Building Officials. (Orders to: International Conference of Building Officials, 5360 S. Workman Mill Rd., Whittier, CA 90601.)

Wagner, Willis H. *Modern Carpentry*. South Holland, Ill.: Goodheart-Willcox Company, Inc., 1979. (Orders to: Goodheart-Willcox Company, Inc., 123 W. Taft Dr., South Holland, IL 60473.)

*Use latest edition available.

Course in Carpentry

MATHEMATICS

Tests

The following section contains objective tests for each topic of the workbook. The value of the objective tests depends to a great extent on the care taken by instructors and school supervisors in keeping them confidential.

Supervisors and instructors should feel free to modify the application of the workbook material and the tests to satisfy local needs. Also, the instructors will probably supplement the information in the workbook with other material that they themselves have developed, and they will need to augment the tests with questions based on any supplementary material they may use.

Removal of the tests either individually or as a complete set may be done at the discretion of the instructor or supervisor.

Mathematics Tests

TOPIC 1 – WHOLE NUMBERS

Decide which one of the four answers is correct, or most correct; then write the corresponding letter in the blank at the right.

1. How many fence posts (posts used to support the lateral materials to which the fencing materials are attached) will be required for a fence 104 feet long if the posts are placed 8 feet center to center? (Posts are also placed at each end of the fence.) 1. ____

   a. 12 c. 14
   b. 13 d. 15

2. If the heat loss from a room during a 9-hour period is 122 175 Btu (British thermal units—the quantity of heat required to raise the temperature of 1 pound of water 1° F. at or near 39.2° F.), what is the heat loss of the room per hour? 2. ____

   a. 13 475 Btu c. 13 575 Btu
   b. 13 557 Btu d. 13 755 Btu

3. How many 31-inch jacks can be cut from a 2 x 4 that is 16 feet long? (Disregard saw kerf.) 3. ____

   a. 5 c. 7
   b. 6 d. 8

4. How many hours will it take two carpenters to install 576 square feet of prefinished plywood paneling if they average three 4- x 8-foot sheets per hours? 4. ____

   a. 6 c. 9
   b. 8 d. 18

5. A job requires 35 blocks each 22 inches long. If these are cut from pieces of material 8 feet long, how many 8-foot pieces will be needed? 5. ____

   a. 8 c. 10
   b. 9 d. 13

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6. What is the total wall area (area = length x width, or height) of a square garage if each of the four walls is 23 feet long and 9 feet high? (Deduct 98 sq. ft. for opening.) 6. ____

a. 189 square feet
b. 287 square feet
c. 730 square feet
d. 782 square feet

7. A carpenter is cutting and laying in place an average of seven 4- x 8-foot sheets of ¾-inch plywood subfloor per hour. How many square feet of subfloor would he average in an 8-hour day? 7. ____

a. 224
b. 1,724
c. 1,762
d. 1,792

8. If the contract price of a job were $18,631 and the total costs of the job were $16,938, how much would the profit be on the job? 8. ____

a. $1,683
b. $1,693
c. $2,703
d. $35,569

9. The costs of accidents and accident prevention are included in the cost to the taxpayers when a new school is built. A contractor's bid was $136,898, which included $2,818.68 for Workers' Compensation insurance. What would be the amount of the bid if this insurance cost were not included? 9. ____

a. $133,069.32
b. $134,069.32
c. $134,079.32
d. $134,080.32

10. A contract for excavation calls for removal of 4,500 cubic yards of earth. Each dump truck hauling from this job takes 5 cubic yards per trip. How many truck loads will remain after 685 loads have been hauled? 10. ____

a. 215
b. 315
c. 3,815
d. 3,915

11. Three pieces each 21 inches long were cut from an 8-foot 2 x 4. How many inches remain? (Disregard saw kerf.) 11. ____

a. 31
b. 32
c. 33
d. 34

12. How many square feet of plywood will remain from an order of 10,016 square feet after 203 sheets each 4 feet x 8 feet in size have been used? 12. ____

a. 3,502
b. 3,520
c. 3,620
d. 4,620

13. The total price of four bags of nails costing $0.64, $1.24, $6.20, and $2.36 is: 13. ____

a. $9.48
b. $10.38
c. $10.42
d. $10.44

14. The rooms and other areas of a house have the following square footages: 14. ____

Entry	76	Bedroom No. 2	165
Living room	308	Bedroom No. 3	134
Dining room	156	Bath	63
Kitchen	122	Service area	92
Bedroom No. 1	180	Garage	328

What is the total number of square feet in the house and garage?

a. 1,562
b. 1,624
c. 1,626
d. 1,642

15. The total number of feet in the perimeter (the distance around the outside limits of an object) of a building with sides 33, 48, 33, and 48 feet long is: 15. ____

a. 114
b. 129
c. 162
d. 1,984

MATHEMATICS TESTS

TOPIC 2 – FRACTIONS

Decide which one of the four answers is correct, or most correct; then write the corresponding letter in the blank at the right.

1. A stair has a total rise of 114 inches; the ideal riser height is considered to be 7 inches. How many risers will this stair have, and what will be the exact unit of rise? 1. ____

   a. 17 risers at $6\frac{7}{8}$ inches
   b. 16 risers at $7\frac{1}{8}$ inches
   c. 16 risers at 7 inches
   d. 15 risers at $7\frac{1}{8}$ inches

2. An elevation plan indicates that there are seven equally spaced 4 x 4 posts ($3\frac{5}{8}$ in. x $3\frac{5}{8}$ in. net size) supportin[illegible]porch roof. The overall dimension from the outside of the first post to the outside of the last is 42 feet $9\frac{5}{8}$ inches. What is the spacing of the porch posts center to center? 2. ____

   a. 6 feet $1\frac{3}{8}$ inches
   b. 6 feet 2 inches
   c. 7 feet 1 inch
   d. 7 feet $1\frac{3}{8}$ inches

3. Three shelves of $\frac{3}{4}$-inch material are equally spaced in a cabinet with an inside dimension of $43\frac{3}{4}$ inches. What is the distance between the shelves? 3. ____

   a. $10\frac{3}{8}$ inches
   b. $10\frac{15}{16}$ inches
   c. $13\frac{5}{16}$ inches
   d. $14\frac{7}{12}$ inches

4. How many sheets of $\frac{3}{8}$-inch plywood are contained in a stack 2 feet $4\frac{1}{2}$ inches high? 4. ____

   a. 75
   b. 76
   c. 78
   d. 87

5. How many boards of 6-inch siding (covering $5\frac{1}{2}$ inches) will be required to cover a side of a framed wall 8 feet 3 inches high? 5. ____

   a. 18
   b. 19
   c. 20
   d. 21

6. A foundation section is 8 inches wide and 30 inches high, and the perimeter is 75 feet 0 inches. How many cubic feet of concrete will be required to fill this form? 6. ____

   a. 100
   b. 125
   c. 130
   d. 150

7. A carpenter installing door units spends about one-third of his time adjusting the door on the hinges and nailing the door stop. How much time does he spend in doing this adjusting in an 8-hour day? 7. ____

   a. 2 hours
   b. 2 hours 20 minutes
   c. 2 hours 30 minutes
   d. 2 hours 40 minutes

8. Mill and end waste (the portion of wood trimmed away) for 1 x 8 drop siding (a type of wood siding normally placed horizontally on a building) is figured at $\frac{1}{5}$. How many board feet of siding should be ordered to cover 480 square feet of wall area? 8. ______

a. 392
b. 480
c. 488
d. 576

9. The take-home pay of a certain carpenter is $360 per week. An on-the-job injury, however, prevents the carpenter from working for a period of 19 weeks. During this time she receives Workers' Compensation benefit payments of $105 each week. The difference between the carpenter's regular pay and the amount she receives in benefit payments is: 9. ______

a. $4,725
b. $4,845
c. $4,875
d. $4,935

10. A platform of a stair is eight risers (the vertical step of a stair) from the top of the first floor to the top of the platform. The risers are $6\frac{7}{8}$ inches each. What is the height of the platform above the first floor? 10. ______

a. 48 inches
b. 54 inches
c. 55 inches
d. 56 inches

11. A hole with a diameter of $2\frac{1}{8}$ inches is bored for a lock that is to have a $2\frac{3}{8}$-inch backset (the distance from the center of the lockset [handle portion] to the edge of the door). How far is the edge of the hole from the edge of the door? 11. ______

a. $4\frac{1}{2}$ inches
b. $2\frac{1}{4}$ inches
c. $1\frac{5}{8}$ inches
d. $1\frac{5}{16}$ inches

12. A reading taken with a builder's transit level indicates that the top of a pier is $25\frac{1}{8}$ inches below the bottom of a floor joist. If the girder used is 4 x 8 ($3\frac{1}{2}$ in. x $7\frac{1}{2}$ in.), what will be the length of the pier post? 12. ______

a. $17\frac{1}{8}$ inches
b. $17\frac{3}{8}$ inches
c. $17\frac{5}{8}$ inches
d. $17\frac{7}{8}$ inches

13. A cabinet $76\frac{1}{4}$ inches long has a plastic top that projects $\frac{3}{4}$ inch. The wall on which the cabinet is installed is 9 feet $\frac{1}{8}$ inch. How much space remains for the refrigerator? 13. ______

a. $30\frac{1}{8}$ inches
b. $30\frac{3}{8}$ inches
c. $30\frac{5}{8}$ inches
d. $30\frac{7}{8}$ inches

14. A door opening is framed in an exterior wall that has a stud length of $92\frac{1}{2}$ inches. The header (a beam over a window or door to support the load above) is a 4 x 12 ($3\frac{1}{2}$ in. x $11\frac{3}{8}$ in.) and is framed without upper jack studs. What is the length required for the trimmer (the vertical framing member supporting each end of the header)? 14. ______

a. $80\frac{5}{8}$ inches
b. $81\frac{1}{8}$ inches
c. $99\frac{3}{4}$ inches
d. $104\frac{1}{8}$ inches

15. An eight-penny nail ($2\frac{1}{2}$ inches long) is driven through a piece of $\frac{5}{8}$-inch plywood subfloor into the joist. How much nail is in the joist? 15. ____

a. $1\frac{3}{4}$ inches
b. $1\frac{7}{8}$ inches
c. $1\frac{15}{16}$ inches
d. $2\frac{1}{8}$ inches

16. A toolbox has inside dimensions of $7\frac{7}{8}$ inches wide, $9\frac{1}{4}$ inches deep, and $29\frac{1}{2}$ inches long. The ends and bottom are $\frac{5}{8}$ inch thick, and the top and sides are of $\frac{1}{4}$-inch exterior grade plywood. What are the outside dimensions, in inches, of the toolbox with the top closed? 16. ____

a. $8\frac{3}{8}$ x $10\frac{3}{8}$ x $29\frac{3}{4}$
b. $8\frac{3}{8}$ x $10\frac{1}{8}$ x 30
c. $8\frac{1}{4}$ x $10\frac{1}{8}$ x $29\frac{3}{4}$
d. $8\frac{3}{8}$ x $10\frac{1}{8}$ x $30\frac{3}{4}$

17. The width between the rails of a job-built ladder may be the same at the top and bottom or may be narrower at the top than at the bottom. If a narrower top is preferred, each succeeding rung from the bottom upward must not be more than $\frac{1}{4}$ inch shorter than the one below. If a ladder is 12 feet tall and the inside width at the bottom rung is 16 inches, what will be the inside width at the top rung if the rungs are 12 inches apart and the maximum allowable reduction is used? 17. ____

a. $12\frac{1}{2}$ inches
b. 13 inches
c. $13\frac{1}{2}$ inches
d. 14 inches

18. A kitchen sink cabinet has a top of $\frac{3}{4}$-inch sheathing, $\frac{3}{8}$-inch ceramic tile, and a $\frac{1}{2}$-inch mortar bed. If the working height of 36 inches from the floor to the top of the tile is maintained, what is the height of the cabinet's sink top frame above the floor? 18. ____

a. $34\frac{3}{8}$ inches
b. $34\frac{5}{8}$ inches
c. $35\frac{3}{8}$ inches
d. $35\frac{5}{8}$ inches

19. The building code in a certain area requires a clearance of 18 inches under floor joists. If a building in this area is constructed with joists $7\frac{9}{16}$ inches wide, subfloor $\frac{5}{8}$ inch thick, and finish floor of $\frac{13}{16}$-inch oak, how high above the grade must the top of the finish floor be? 19. ____

a. $26\frac{11}{16}$ inches
b. 27 inches
c. $27\frac{1}{16}$ inches
d. $27\frac{1}{8}$ inches

20. In determining the total rise of a stair, a carpenter must add the exact dimensions of the following: 20. ____

Upper finish floor....................	$^5/_{16}$ inch
Upper subfloor	$^3/_4$ inch
Width of floor joists	$11^1/_2$ inches
Thickness of two top plates (each).....	$1^1/_2$ inches
Thickness of bottom plate	$1^1/_2$ inches
Stud length	$92^1/_2$ inches

How much must the carpenter add to the stud length to get the total height of this stair?

a. $17^5/_{16}$ inches
b. $17^1/_{16}$ inches
c. $17^1/_2$ inches
d. $17^5/_8$ inches

MATHEMATICS TESTS

TOPIC 3 – DECIMALS

Decide which one of the four answers is correct, or most correct; then write the corresponding letter in the blank at the right.

1. A rule-of-thumb safe load-hoisting capacity for wire rope may be determined by moving the decimal point four places to the right in the figure for cable weight indicated in hundredths of pounds per foot. A safety factor of 6 is included in this rule, and it can be applied to cable up to an inch in diameter. For example, $\frac{1}{4}$-inch-diameter cable weighs 0.10 pound per foot, so in the moving of the decimal point four places to the right, 0.10 pound becomes 1,000 pounds. If the weight of $\frac{5}{8}$-inch cable is 0.63 pound per foot, what is the maximum load allowance? 1. ____

   a. 63.0 pounds
   b. 630 pounds
   c. 6,300 pounds
   d. 63,000 pounds

2. Two men installed 22 sheets of 4- x 8-foot prefinished plywood paneling in an 8-hour day. What fractional part of a labor hour is required per square foot? 2. ____

   a. 0.022 hour
   b. 0.22 hour
   c. 0.28 hour
   d. 0.40 hour

3. A swimming pool is 18 feet x 27 feet and averages 5.75 feet in depth. How many cubic feet of water will it contain? 3. ____

   a. 2,790.50
   b. 2,794.50
   c. 2,798.50
   d. 2,894.50

4. A brick veneered wall 8 feet high and $22\frac{1}{2}$ feet long is figured at 6.85 bricks per square foot. How many bricks will be required? 4. ____

   a. 1,223
   b. 1,233
   c. 1,645
   d. 6,650

5. A builder uses \$14.75 per square foot in estimating the cost of a dwelling. What should his bid be on a house with 1,685 square feet? 5. ____

   a. \$24,853.75
   b. \$24,943.75
   c. \$24,953.75
   d. \$25,852.75

6. A contractor's bid on a small alteration job was \$1,896. She paid \$738.78 in labor costs and \$958.82 for materials. How much profit did she make on the job? 6. ____

   a. \$198.40
   b. \$198.60
   c. \$208.40
   d. \$208.60

7. The original bid for a commercial building was $168,598.50. The specifications were modified to reduce the cost by $6,438. However, by the time the building was completed, authorized extras totaled $1,306.26. What was the final cost of the building? 7. ____

a. $162,466.76
b. $162,646.76
c. $163,466.76
d. $163,644.76

8. A builder's level is set-up over Point X. The rod readings taken without moving the setup were Point A, 4.24 feet and Point B, 7.4 feet. Which of the following statements is true? 8. ____

a. Point A is 3.16 feet higher than Point B.
b. Point A is 3.16 feet lower than Point B.
c. Point A is 7.4 feet higher than Point X.
d. Point B is 7.4 feet lower than Point X.

9. Based on county building permits issued, the total value of construction over a four-month period was as follows: 9. ____

September	$934,583.94
October	728,223.68
November	822,423.00
December	682,493.95

What was the greatest dollar value difference that occurred in any two consecutive months?

a. $199,929.05
b. $206,360.26
c. $252,089.99
d. $294,199.32

10. The net worth of a business is equal to its assets minus its liabilities. What is the net worth of a business with the following assets and liabilities? 10. ____

Assets

Accounts receivable	$5,982.38
Cash on hand	736.26
Equipment	4,967.25
Supplies	1,348.00

Liabilities

Accounts payable	$1,843.24
Notes payable	2,784.78
Other liabilities	1,873.88

a. $6,501.90
b. $6,531.89
c. $6,531.99
d. $6,532.99

11. In a given year 98.8 construction workers per 1,000 suffered lost-time injuries. If 200,000 workers were employed in that year, how many lost time because of injuries? 11. ____

a. 9,880 c. 29,760
b. 19,760 d. 39,760

12. The plot plan for a construction site is dimensioned in engineer's dimensions of feet and hundredths of feet. The north side of the lot is 91.65 feet; the east side is 150.81 feet; the south side is 91.65 feet; and the west side is 125.69 feet. What is the length, in feet, of the chain link fence required to enclose the lot? 12. ____

a. 450.80 c. 459.80
b. 450.89 d. 469.80

13. Elevations and grades are designated in feet and hundredths of feet instead of feet and inches. A bench mark, Point X, is assigned an elevation of 100 feet. A rod reading over Point A indicates that it is 6.75 feet higher than Point X. Point B is 7.83 feet higher than Point A. Point C is 5.17 feet above Point B. What is the elevation of Point C? 13. ____

a. 19.65 feet c. 119.65 feet
b. 19.75 feet d. 119.75 feet

14. What is the new balance of a contractor's $5,029.42 bank account after checks of the following amounts are deposited: $568.63, $29.42, $29.42, $500, and $9.84? 14. ____

a. $6,066.63 c. $6,166.73
b. $6,137.31 d. $6,167.73

15. As an apprentice carpenter, you furnish your own hand tools. What amount would you have to spend to make the initial tool purchase listed below? 15. ____

1 8-point hand saw	$15.95
1 16-ounce hammer	6.35
1 combination square	4.55
1 12-foot pocket tape	4.15
1 chalk line with chalk	2.37
1 12-inch adjustable wrench	6.98
1 8-inch side cutter pliers	5.85
1 8-inch screwdriver	1.49
1 pocket knife	4.00
1 locking-type toolbox	16.77
1 pair of overalls	11.99

a. $80.45 c. $81.45
b. $80.85 d. $82.65

MATHEMATICS TESTS

TOPIC 4 – PERCENT

Decide which one of the four answers is correct, or most correct; then write the corresponding letter in the blank at the right.

1. A contractor bid successfully on a large addition and remodeling job at \$19,516.92 contract price. After the job was completed, he discovered his cost was \$20,120.54. What was the percent of loss for labor, materials, and so forth on this job? 1. ____

a. 2.5 percent
b. 3 percent
c. 3.5 percent
d. 4 percent

2. A builder sold a house for \$25,251.52 after figuring all his costs at \$22,546. What was his percent of profit based on his total costs? 2. ____

a. 10 percent
b. 12 percent
c. 13 percent
d. 15 percent

3. The mill waste allowance for a 1 x 10 "v" rustic is 10 percent, and end waste is 8 percent. How much should be ordered if the area to be covered is 585 square feet? 3. ____

a. 630 square feet
b. 680 square feet
c. 690 square feet
d. 980 square feet

4. A real estate agent usually collects from the seller for her services an amount set as a percent of the selling price. This is called a commission. If she sold a house for \$19,595 at a 6 percent commission, how much would the contractor receive? 4. ____

a. \$18,419.30
b. \$19,478.43
c. \$19,595.00
d. \$19,419.43

5. A contractor's percent of profit is sometimes based on the actual total costs of materials, labor, and so forth. If total costs were estimated at \$24,096 for construction of a home and if the contractor wanted a profit of 12 percent, what would the bid be? 5. ____

a. \$24,385.15
b. \$26,096.12
c. \$26,987.52
d. \$27,381.82

6. An apprentice carpenter purchased some of her tools at a 12 percent discount. What was her actual cost if the regular price was \$24.95? ____

a. \$21.06
b. \$21.96
c. \$24.83
d. \$29.94

7. One-third of the actual cost of a home in a new subdivision goes for land and site development. What is one-third written as a percent? 7. ____

a. 0.33 percent
b. 0.333 percent
c. 3.33 percent
d. $33\frac{1}{3}$ percent

8. Twelve and one-half hundredths written as a percent would be: 8. ____

a. $0.12\frac{1}{2}$ percent
b. 0.125 percent
c. $12\frac{1}{2}$ percent
d. 125 percent

9. The decimal fraction 0.75 converted to a percent is written: 9. ____

a. 0.75 percent
b. $7\frac{1}{2}$ percent
c. 75 percent
d. 750 percent

10. In a whole number the decimal is understood after the units figure. A percent may be changed to a decimal fraction by moving the decimal point two places: 10. ____

a. To the right and keeping the percent sign
b. To the right and dropping the percent sign
c. To the left and dropping the percent sign
d. To the left and keeping the percent sign

MATHEMATICS TESTS

TOPIC 5 – CONVERSION OF UNITS

Decide which one of the four answers is correct, or most correct; then write the corresponding letter in the blank at the right.

1. An area to be planted into lawn is to have a layer of topsoil spread 6 inches deep. How many square feet of the area can be covered with each 5-yard dump truck load? 1. ____

a. 250   c. 270
b. 260   d. 280

2. A concrete slab is to be 26 feet long, 24 feet 6 inches wide, and 4 inches thick. How many cubic yards of concrete should be ordered? (Order to the next whole cubic yard.) 2. ____

a. 6   c. 8
b. 7   d. 9

3. How many square feet are contained in 1,728 square inches? 3. ____

a. 11   c. 13
b. 12   d. 144

4. The average length of time required for a carpenter to install a magnetic catch on a cabinet door is 8 minutes. At a wage rate of $10.40 per hour, what will be the cost of installing 45 such pieces of hardware? 4. ____

a. $62.30   c. $62.60
b. $62.40   d. $64.20

5. The first floor elevation is noted on the plans in engineer's measurements as 84.62 feet. The second floor is 13 feet 9 inches above the first. What is the elevation of the second floor in engineer's measurements? 5. ____

a. 97.37 feet   c. 98.37 feet
b. 97.71 feet   d. 98.71 feet

6. A commercial building has a floor area of 15,786 square feet to be covered with carpeting wall to wall. The general contractor's price for laying this carpet is $5.60 per square yard. How much will the contractor's labor cost? 6. ____

a. $9,822.40   c. $9,922.40
b. $9,842.40   d. $9,932.60

7. A room has a ceiling height of 9 feet 5 inches and a 17-inch soffit. What is the ceiling height of that part of the room under the soffit? 7. ____

a. 7 feet 8 inches   c. 8 feet 5 inches
b. 8 feet 0 inches   d. 9 feet 0 inches

8. How many cubic yards are contained in an excavation 38 feet x 26 feet x 7 feet deep? (Figure to the next whole cubic yard.) 8. ____

a. 256
b. 257
c. 768
d. 769

9. How many feet of $1\frac{1}{8}$-inch glass stop (trim approximately $\frac{3}{8}$ in. by 1 in. used to hold a piece of glass in a wood frame) are required for stationary sash (a window part that cannot be opened) of the following dimensions (outside of window only)? 9. ____

3 lights	32 inches x 68 inches
2 lights	44 inches x 32 inches
5 lights	26 inches x 14 inches

(Add 6 ft. for waste allowance, and increase to the next whole foot.)

a. 108
b. 114
c. 115
d. 116

10. How many linear feet (1 linear foot = 12 inches) of No. 9 tie wire (9-gauge wire used for formwork) will be needed to make 36 form ties each 44 inches in length? 10. ____

a. 130
b. 132
c. 1,132
d. 1,584

MATHEMATICS TESTS

TOPIC 6 – COMPOUND NUMBERS

Decide which one of the four answers is correct, or most correct; then write the corresponding letter in the blank at the right.

1. A sidewalk 3 feet wide and 38 feet long is to be divided into 12 equal spaces for expansion joints. What is the distance between joints? 1. ____

   a. 3 feet 0 inches
   b. 3 feet 2 inches
   c. 3 feet 4 inches
   d. 4 feet 3 inches

2. In stable soil the sides of an excavation cut may be sloped $\frac{3}{4}$ to 1 (horizontal to vertical). If an excavation is 10 feet 6 inches deep, what would be the exact horizontal distance from the edge of the excavation to the bottom line of the slope? 2. ____

   a. 7 feet $1\frac{7}{8}$ inches
   b. 7 feet $10\frac{1}{2}$ inches
   c. 8 feet $\frac{1}{2}$ inch
   d. 8 feet $10\frac{1}{2}$ inches

3. A girder run of 49 feet 6 inches is to be supported by five equally spaced piers (ends of girders on the foundation). What is the spacing of the piers? 3. ____

   a. 8 feet 3 inches
   b. 8 feet 10 inches
   c. 9 feet 3 inches
   d. 9 feet 10 inches

4. How many cubic feet are contained in a room 14 feet 8 inches x 18 feet 3 inches x 8 feet 6 inches? (Figure to the next even foot.) 4. ____

   a. 2,157
   b. 2,175
   c. 2,257
   d. 2,276

5. How many linear feet of material are required to cut 84 pieces each 1 foot 9 inches long? (Figure to the next whole foot.) 5. ____

   a. 147
   b. 148
   c. 156
   d. 158

6. Two pieces of 2 x 10 joist 7 feet 3 inches and 6 feet 8 inches are cut from a piece 16 feet 0 inches long. How much remains? 6. ____

   a. 1 foot 1 inch
   b. 1 foot 11 inches
   c. 2 feet 1 inch
   d. 2 feet 11 inches

7. A foundation and footing require $18\frac{1}{2}$ cubic yards of concrete. In addition, 18 piers contain $1\frac{1}{2}$ cubic feet each, and a fireplace footing contains 13 cubic feet. How many cubic yards of concrete are needed for the foundation, footings, and piers? (Figure to the next full cubic yard.) 7. ____

   a. 18
   b. 19
   c. 20
   d. 21

80

8. If the width of a room is 6 feet 9 inches and the width of the room next to it is 9 feet 3 inches, what is the combined width of the two rooms? 8. ____

a. 15 feet 9 inches
b. 16 feet 0 inches
c. 16 feet 1 inch
d. 16 feet 6 inches

9. What is the overall width of a fireplace hearth with intermediate dimensions of $11\frac{1}{2}$ inches, 3 feet 1 inch, and $11\frac{1}{2}$ inches? 9. ____

a. 4 feet $11\frac{1}{2}$ inches
b. 5 feet 0 inches
c. 5 feet $\frac{1}{2}$ inch
d. 5 feet 3 inches

10. Before beginning construction, a carpenter should check intermediate dimensions to ensure that they equal the overall dimensions shown on the plans. If the following dimensions were added, they would total what overall length? 10. ____

5 feet 6 inches
5 feet 3 inches
5 feet 3 inches
3 feet 4 inches
5 feet 3 inches
5 feet 9 inches
5 feet $7\frac{1}{2}$ inches

a. 34 feet $10\frac{1}{2}$ inches
b. 35 feet $10\frac{1}{2}$ inches
c. 35 feet $11\frac{1}{2}$ inches
d. 36 feet $11\frac{1}{2}$ inches

MATHEMATICS TESTS

TOPIC 7 – DECIMAL AND FRACTIONAL EQUIVALENTS

Decide which one of the four answers is correct, or most correct; then write the corresponding letter in the blank at the right.

1. An accurate method of determining line length of a rafter is to convert the unit of diagonal or bridge measure to inches and hundredths and multiply by the number of units of run. The diagonal of a 7 and 12 cut is $13\frac{29}{32}$ inches. Converted to inches and nearest hundredths of an inch, this would be: 1. ____

   a. 13.32 inches
   b. 13.70 inches
   c. 13.75 inches
   d. 13.91 inches

2. A stair shown on a plan has 15 risers. The difference in floor elevations as figured from engineer's dimensions is 9.06 feet. What will be the height of each riser in inches? 2. ____

   a. $7\frac{7}{32}$ inches
   b. $7\frac{1}{4}$ inches
   c. $7\frac{3}{16}$ inches
   d. $7\frac{5}{32}$ inches

3. Certain specifications call for safety glass with a minimum thickness of 0.1875 inch. Converted to the nearest 16th of an inch, 0.1875 inch is: 3. ____

   a. $\frac{1}{16}$ inch
   b. $\frac{2}{16}$ inch
   c. $\frac{3}{16}$ inch
   d. $\frac{4}{16}$ inch

4. The thickness of vinyl asbestos floor tile is noted in the manufacturer's specifications as 0.125 inch. A thickness of 0.125 inch converted to a measurement found on the carpenter's tape is: 4. ____

   a. $\frac{1}{16}$ inch
   b. $\frac{1}{8}$ inch
   c. $\frac{3}{32}$ inch
   d. $\frac{3}{16}$ inch

5. The finish floor elevation of a garage is 72.25 feet. The first floor of the house is 18 inches above the garage. The difference in the first and second floor is 10 feet $9\frac{1}{2}$ inches. What is the elevation of the second floor in feet and hundredths of feet? 5. ____

   a. 84.46 feet
   b. 84.50 feet
   c. 84.54 feet
   d. 84.65 feet

6. A lot is shown on a plot plan as being 85.66 feet wide. The building to be set on the lot is 44 feet 8 inches wide and has a 12-foot setback from the property line on one side. How much is the setback on the other side of the lot (in feet and inches)? 6. ____

   a. 28 feet $10\frac{1}{4}$ inches
   b. 29 feet 0 inches
   c. 29 feet $10\frac{5}{16}$ inches
   d. 30 feet 0 inches

82

7. The rod reading at the curb end of a driveway is 4.82 feet and at the garage door 4.28 feet. What is the slope of the driveway to the nearest $^1/_{16}$ inch? 7. ____

a. 5 inches
b. $5^7/_{16}$ inches
c. 6 inches
d. $6^3/_4$ inches

8. The results of a survey indicate that a sewer line is 7 feet 3 inches below the street level, which is at an elevation of 83.45 feet. The local building code requires that the minimum fall of the sewer line of a house be 3 feet 6 inches and that the top of the sewer line of a house be 2 feet 0 inches below the finish floor of the house. The minimum elevation that the finish floor of a house can be is: 8. ____

a. 80.70 feet
b. 81.20 feet
c. 81.70 feet
d. 87.10 feet

9. A journey-level carpenter's rate of pay is $17.55 per hour. What would be the carpenter's wages for $5^3/_4$ hours of work? 9. ____

a. $58.50
b. $59.35
c. $100.91
d. $105.30

10. The elevation of 96.45 feet on the first-floor plan is in engineer's dimensions, feet and hundredths of a foot. The difference in floor levels is 9 feet 9 inches. The elevation of the second floor in feet and hundredths of a foot will be: 10. ____

a. 105.90
b. 106.20
c. 106.35
d. 106.90

TOPIC 8 — PERIMETERS, AREAS, AND VOLUMES

Decide which one of the four answers is correct, or most correct; then write the corresponding letter in the blank at the right.

1. A circular swimming pool is 25 feet in diameter and averages 5 feet 6 inches deep. How many gallons of water are needed to fill this pool? (One cubic foot contains $7\frac{1}{2}$ gallons.) 1. ____

   a. 18,800 c. 20,250
   b. 19,250 d. 20,500

2. The cross section of a round heat duct is figured to determine the correct size to be used. How many square inches are contained in an 8-inch 26-gauge duct? 2. ____

   a. 48 c. 52
   b. 50 d. 54

3. A circular storage silo (a circular storage bin) must be plastered on the inside for waterproofing. How many square yards of plaster will the job take if the inside diameter is 21 feet and the height is 35 feet? 3. ____

   a. 225 c. 275
   b. 260 d. 325

4. Sono tubes (paper tubing used for pouring concrete columns) 15 inches in diameter are used for column forms in the construction of a hillside home. How many cubic feet of concrete are required to fill a tube 10 feet long? (Figure to the next half cubic foot.) 4. ____

   a. $11\frac{1}{2}$ c. $12\frac{1}{2}$
   b. 12 d. $13\frac{1}{2}$

5. Two pieces of redwood batten $\frac{3}{8}$ of an inch thick and 4 inches wide are to be nailed together to form the edge of a circular flower bed that has a diameter of 6 feet. What length of material, in feet, should be ordered to avoid unnecessary splices and waste? 5. ____

   a. Two 20 footers c. Two 18 footers
   b. Two 19 footers d. One 38 footer

6. What would be the weight of a fir timber that measures 12 inches x 18 inches x 28 feet 0 inches? (Douglas fir weighs 32 lb. per cubic foot.) 6. ____

   a. 134.4 pounds c. 1,304 pounds
   b. 143.4 pounds d. 1,344 pounds

7. How many cubic yards of concrete should be ordered to construct an apron 4 inches thick and 42 inches wide around a square graveled parking area that is 86 feet 6 inches on a side? (Figure to the next whole cubic yard.) 7. ____

a. 12
b. 14
c. 16
d. 18

8. A cold storage room is 18 feet by 25 feet 6 inches with a ceiling height of 7 feet 3 inches. The size of the freezing unit is based on the volume of space to be maintained at zero degrees temperature. The refrigerating unit should have the capacity to cool: 8. ____

a. 240 cubic feet
b. 340 cubic feet
c. 2,400 cubic feet
d. 3,400 cubic feet

9. A battered foundation (a foundation with one vertical wall and one sloped wall) is 8 inches wide at the top, 16 inches wide at the bottom, and an average of 30 inches high. What is the cubic content per linear foot? 9. ____

a. $2\frac{1}{4}$
b. $2\frac{1}{2}$
c. $2\frac{3}{4}$
d. $3\frac{1}{2}$

10. The foundation detail gives the size of column footings (an underground concrete base that supports a column or post) as 2 feet 6 inches square and 12 inches thick. How many cubic feet of concrete are required to pour 18 footings? 10. ____

a. 11.25
b. 112.5
c. 121.5
d. 121.68

11. To draw correctly (remove smoke), a fireplace must have a flue with a cross section area equal to a minimum of $\frac{1}{10}$ the area of the fireplace opening. What is the correct size terra cotta flue lining for a fireplace opening 42 inches wide and 31 inches high? 11. ____

a. 8 inches x 10 inches
b. 10 inches x 10 inches
c. 10 inches x 12 inches
d. 10 inches x 14 inches

12. What is the area of a gable end (the triangular end of an exterior wall above the eaves) with a total rise of 6 feet 6 inches and a total run of 13 feet 0 inches? 12. ____

a. $40\frac{1}{3}$ square feet
b. $42\frac{1}{4}$ square feet
c. $84\frac{1}{2}$ square feet
d. $85\frac{3}{4}$ square feet

13. An acre contains 43,560 square feet. A plot plan indicates that a piece of property is 104.35 feet wide and 108.70 feet deep. Which of the following is closest to the acreage in the parcel? 13. ____

a. 0.245
b. 0.260
c. 0.265
d. 0.270

14. How many square yards of carpet are needed to cover a 12-foot-square room? 14. ____

a. 16
b. 18
c. 46
d. 48

15. How many square feet of concrete slab are in a garage that measures 22 feet 0 inches x 22 feet 6 inches? 15. ____

a. 495
b. 496
c. 497
d. 498

16. A front door has nine lights (pieces of glass) that must be "molded in" (enclosed by a molding). If each light is $6\frac{3}{4}$ inches x 10 inches, how much molding would be required? (Calculate to the next even foot.) 16. ____

a. 22 feet
b. 24 feet
c. 26 feet
d. 28 feet

17. A $\frac{1}{2}$- x $1\frac{1}{4}$-inch redwood glass stop is to be applied to the inside and outside of a plate glass window on both sides and the top only. The glass to be used is 66 inches wide and 86 inches high. Which of the following orders would be the most economical? (Allow for the least waste.) 17. ____

a. Two 14-foot pieces and two 10-foot pieces
b. Four 8-foot pieces and two 6-foot pieces
c. Two 14-foot pieces and two 10-foot pieces
d. Four 8-foot pieces and one 10-foot piece

18. The lengths of exterior walls of a building have the following measurements: 19 feet 6 inches, 18 feet $7\frac{1}{2}$ inches, 3 feet 5 inches, 14 feet 6 inches, 22 feet 11 inches, and 33 feet $1\frac{1}{2}$ inches. What is the perimeter of this building? 18. ____

a. 112 feet 0 inches
b. 112 feet 1 inch
c. 112 feet $1\frac{1}{2}$ inches
d. 113 feet 0 inches

19. Chain link fencing is to be used to enclose a storage yard 46 feet 8 inches by 32 feet 0 inches. The fence is to be 6 feet 0 inches high. How many square feet of fencing will be required? (Deduct 6 ft. 0 in. for a prefabricated gate, and figure no waste allowance.) 19. ____

a. 808
b. 844
c. 908
d. 944

20. What quantity of 2 x 4s will be required to make a bottom plate (exterior wall only) of a building that is 38 feet 6 inches square (no waste allowance)? 20. ____

a. 122 feet 3 inches
b. 137 feet 6 inches
c. 144 feet 8 inches
d. 154 feet 0 inches

MATHEMATICS TESTS

TOPIC 9 – SQUARES AND SQUARE ROOT

Decide which one of the four answers is correct, or most correct; then write the corresponding letter in the blank at the right.

1. As a rule of thumb, the safe-load limit of shackles can be determined by finding the diameter of the shackle pin in ¼-inch increments. This number squared and divided by 3 equals the capacity of the shackles in tons. For example, a 2-inch diameter contains 8 quarters, $8 \times 8 = 64$, and $64 \div 3 = 21\frac{1}{3}$ tons. If a shackle pin is 1½ inches in diameter, what is the safe load in pounds (1 tn. = 2,000 lb.)? 1. _____

   a. 12,000 c. 24,000
   b. 20,000 d. 29,000

2. A square concrete patio is made up of precast concrete sections measuring 18 inches x 18 inches. How many pieces are on a side if the patio contains 441 square feet? 2. _____

   a. 14 c. 18
   b. 15 d. 21

3. The intake or cold-air return in a forced-air furnace of 125 000 Btu requires 324 square inches. If the cold-air return in the ceiling is square, what will be its dimensions? 3. _____

   a. 15 inches x 15 inches c. 16 inches x 16 inches
   b. 17½ inches x 17½ inches d. 18 inches x 18 inches

4. During construction of a building, a safety cable must be used around the perimeter of the floor under construction. How many feet of safety cable are required to go around the perimeter of a square office building that has six stories and a total floor area of 331,350 square feet? 4. _____

   a. 235 c. 552
   b. 470 d. 940

5. A square excavation had 128 cubic yards of dirt removed to make it 6 feet deep. How long was each side of the excavation? 5. _____

   a. 8 feet 0 inches c. 24 feet 0 inches
   b. 11 feet 2½ inches d. 36 feet 0 inches

6. A square storage room must have a floor area of approximately 170 square feet. What would be the dimensions of this room? 6. _____

   a. 12 feet 0 inches x 12 feet 0 inches
   b. 12 feet 6 inches x 12 feet 6 inches
   c. 13 feet 0 inches x 13 feet 0 inches
   d. 13 feet 4 inches x 13 feet 4 inches

7. What is X in the mathematical equation $X = \sqrt{36} \times 6$? 7. ______

a. $X = 6$
b. $X = 36$
c. $X = 36 \div 6$
d. $X = 42$

8. The radical sign ($\sqrt{\quad}$) placed over a number indicates which of the following: 8. ______

a. The number is to be multiplied by itself.
b. Some number multiplied by 2 will equal this given number.
c. This number is to be multiplied by the exponent. (If there is no exponent, it is assumed to be 2.)
d. An unknown number multiplied by itself will equal this given number.

9. Manila rope is frequently used for hoisting loads on the job. A safe load can be determined by using the following rule: Capacity in tons is equal to the diameter of the rope in inches squared. What would be a maximum-safe load for a manila rope with a $\frac{3}{4}$-inch diameter? 9. ______

a. $\frac{1}{4}$ ton
b. $\frac{1}{2}$ ton
c. $\frac{5}{8}$ ton
d. $\frac{3}{4}$ ton

10. The expressions *two square feet* and *two feet square* are confusing to some people. What is meant mathematically by the expression *two feet square?* 10. ______

a. 1 foot x 2 feet
b. 2 feet
c. 2 feet^2
d. $\frac{2 \text{ feet}}{2 \text{ feet}}$

MATHEMATICS TESTS

TOPIC 10 — THE RIGHT TRIANGLE

Decide which one of the four answers is correct, or most correct; then write the corresponding letter in the blank at the right.

1. The cut of a common rafter is 6 inches in 12 inches, with a run of 14 feet 6 inches. What is the area of one end of the building, including the wall area, if the wall height is 9 feet 0 inches from foundation line to horizontal line of the roof triangle? 1. ____

   a. 211 square feet
   b. 237 square feet
   c. 367 square feet
   d. 472 square feet

2. A right triangle may be thought of as half of a rectangle. In a right triangle with a height, or altitude, of 7.5 feet and a run, or base, of 14.75 feet, what is the area (rounded to the next whole square foot)? 2. ____

   a. 55 square feet
   b. 56 square feet
   c. 110 square feet
   d. 111 square feet

3. A stair has a total rise of 8 feet $11^1/_2$ inches and a total run of 12 feet 3 inches. What length of 2 x 12 plank should be ordered for the stair horse (to the next even foot)? (Measure the diagonal on the twelfths scale of the framing square.) 3. ____

   a. 14 feet
   b. 15 feet 3 inches
   c. 16 feet
   d. 18 feet

4. A ladder placed against a building forms a right triangle. The base (the distance from the building to the foot of the ladder) should be one-fourth of the hypotenuse of the triangle thus formed. What should be the distance from the building to the foot of a $22^1/_2$-foot ladder? 4. ____

   a. 4 feet 0 inches
   b. 4 feet 6 inches
   c. 5 feet 0 inches
   d. 5 feet 7 inches

5. Using a steel square, measure the diagonal of a square figure with 10-inch sides. Check this dimension using the tenths scale. The length is: 5. ____

   a. 12.15 inches
   b. 13.15 inches
   c. 14.15 inches
   d. 15.15 inches

6. If the unit of rise of a rafter (the vertical distance through which a rafter rises) is 5 inches and the unit of run (the horizontal distance between the face of a wall and the ridge of a roof) is 12 inches, the unit of rafter length is 13 inches. What will be the rafter length required in a building with a span (the distance between the wall plates of a building or from outside wall to outside wall) of 22 feet 6 inches? 6. ____

   a. $244^1/_2$ inches
   b. 24 feet $4^1/_2$ inches
   c. $146^1/_4$ inches
   d. 14 feet $6^1/_4$ inches

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7. What would be the length of a rafter for a roof with a total rise of 4 feet 8 inches and a total run of 10 feet 8 inches? (Use the steel square and the twelfths scale to calculate the answer.) 7. ____

a. 10 feet 8 inches
b. 10 feet 9 inches
c. 11 feet 6 inches
d. 11 feet 8 inches

8. If the two sides adjoining the 90-degree angle in a right triangle are 16 and 12, what is the length of the side opposite the right angle? 8. ____

a. 20
b. 24
c. 28
d. 32

9. The Pythagorean Theorem applies to: 9. ____

a. The sides of an equilateral trangle
b. The area of a right triangle
c. The length of the hypotenuse of a right triangle
d. The length of the rise plus the run of a common rafter

10. If a right triangle has one angle of 65 degrees, the third angle would be equal to: 10. ____

a. 90 degrees − 65 degrees
b. 90 degrees + 65 degrees
c. 180 degrees − 65 degrees
d. 180 degrees + 65 degrees

MATHEMATICS TESTS

TOPIC 11 – LUMBER PRODUCTS AND BOARD MEASURE

Decide which one of the four answers is correct, or most correct; then write the corresponding letter in the blank at the right.

1. How many board feet are contained in 25 pieces of lumber 2 inches x 10 inches x 12 feet? 1. ____

   a. 400 c. 500
   b. 498 d. 525

2. A contractor purchased 36 planks to build a scaffold. The planks, of Douglas fir Selected Structural grade, were 2 inches x 10 inches x 12 feet 0 inches. The price was $326 per M. How much did the contractor pay for the planks? 2. ____

   a. $224.76 c. $236.72
   b. $234.72 d. $244.72

3. A three-story apartment house is 36 feet x 96 feet in shape. The exterior walls are figured at 8 feet 8 inches per floor. The exterior sheathing is $^3/_8$-inch Ply-score in 4- x 8-foot sheets. Waste allowance is taken care of by not deducting for door and window openings. How many sheets of Ply-score sheathing are required to cover the exterior walls? 3. ____

   a. 207 c. 645
   b. 215 d. 687

4. A list of dimensioned lumber for framing a small house includes the following: 4. ____

   8 pieces of 4 inches x 8 inches x 16 feet
   36 pieces of 2 inches x 8 inches x 12 feet
   20 pieces of 2 inches x 4 inches x 20 feet
   22 pieces of 2 inches x 10 inches x 14 feet
   350 pieces of 2 inches x 4 inches x 8 feet precut studs

   At a price of $256 per M, what is the cost of this material?

   a. $812.76 c. $912.38
   b. $902.38 d. $922.68

5. By scaling the foundation plan, a carpenter estimated that 130 linear feet of 4-inch x 6-inch girder are required. How many board feet do the girders contain? 5. ____

   a. 260 c. 294
   b. 280 d. 302

6. How many board feet are contained in 18 pieces each 2 inches x 4 inches x 16 feet? 6. ____

   a. 144 c. 188
   b. 180 d. 192

7. Which one of the following formulas may be used to determine the number of board feet in any piece of lumber? 7. ____

a. Nominal size × length in feet ÷ 12 = board feet
b. Nominal size × length in feet ÷ 144 = board feet
c. $\frac{1 \times 12 \times 12}{12}$ = board feet
d. Thickness in inches × width in inches × length in feet ÷ 144 = board feet

8. A board foot is an inch thick and a foot square, or any combination of measurements that will equal this amount. Which one of the following measurements contains a board foot? 8. ____

a. 2 inches x 6 inches x 1 foot
b. 1 foot x 4 inches x 3 inches
c. 1 inch x 6 inches x 2 feet
d. All of these

9. If an order for redwood were written for 2 inches x 8 inches rough, the word *rough* would suggest: 9. ____

a. Nominal size
b. A resawn textured surface
c. Imperfections other than knots
d. Oversize lumber to allow for surfacing

10. Which one of the following is not considered in the grading of lumber? 10. ____

a. Species of the tree
b. Percent of moisture content
c. Price per 1,000 board feet (Mb.f.)
d. Spacing of imperfections

MATHEMATICS TESTS

TOPIC 12 – METRIC MEASUREMENTS AND CONVERSION

Decide which one of the four answers is correct. or most correct; then write the corresponding letter in the blank at the right.

1. A yard is equal to how many centimetres? 1. ____

a. 0.9144 c. 91.44
b. 9.144 d. 914.4

2. If a square foot equals 0.0929 square metres, 6 square feet equals how many square metres? 2. ____

a. 0.5574 c. 55.74
b. 5.574 d. 557.4

3. One thousand metres has the prefix: 3. ____

a. Deci c. Milli
b. Centi d. Kilo

4. A kilometre is approximately what part of a mile? 4. ____

a. 1/3 c. 0.75
b. 0.62 d. 0.8

5. The metric system is based on which of the following units? 5. ____

a. 5 c. 15
b. 10 d. 20

6. A length of 1 foot is equal to how many centimetres? 6. ____

a. 24.12 c. 30.48
b. 24.42 d. 39.37

7. The number of inches in a metre is: 7. ____

a. 36.37 c. 39.37
b. 38.16 d. 41.14

8. A kilometre equals how many metres? 8. ____

a. 50 c. 500
b. 100 d. 1 000

9. A hectometre equals how many metres? 9. ____

a. 50 c. 500
b. 100 d. 1 000

10. A decametre equals how many metres? 10. ____

a. 5
b. 10
c. 50
d. 100

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