Carpentry (46.0201) T-Chart

Square a building using the Pythagorean Theorem	=	Apply the properties of rational and irrational numbers to solve real world problems or mathematical problems

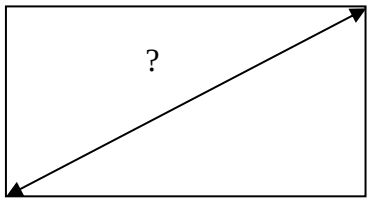
Program Task: Square a building using the Pythagorean Theorem.

Program Associated Vocabulary:
DIAGONAL, DIMENSION, SQUARE, 3-4-5

Program Formulas and Procedures:
To find the diagonal measurement of a square building the measurements of the length and the width must be known; the measurements will be found on the foundation plan or the floor plan. Finding the square root of the length ^{2} + the width ^{2} will give the diagonal dimension of the building.

Example:

Foundation for a Building



12 ft.

17 ft.

Pythagorean Theorem:
$a^2 + b^2 = c^2$
$17^2 + 12^2 = c^2$
$289 + 144 = c^2$
$433 = c^2$
$\sqrt{433} = c$
20.809 ft. = c

Estimation Method to find Square Root:
When carpenters use the Pythagorean Theorem to square a building it is important that the diagonal measurement be correct to the nearest 1/16th of an inch. Carpenters cannot estimate the diagonal because the house will not be square.

Converting 20.809 ft. to the nearest $^1/_{16}$ inch:
Take off the whole number
20 ft.
Multiply decimal by 12 to get inches
$0.809 \times 12 = 9.704$ in.
Take off the whole number
9 in.
Multiply the decimal by 16 to get the nearest $^1/_{16}$
$0.704 \times 16 = 11.261$
20.809 ft. $\approx$ 20 ft. 9 $^{11}/_{16}$ in.

PA Core Standard: CC.2.1.HS.F.2

Description: Apply the properties of rational and irrational numbers to solve real world problems or mathematical problems.

Math Associated Vocabulary:
SQUARE ROOT

Formulas and Procedures:
Find Square Root:

3 in.

Area = 3 in. x 3 in.
Area = 9 in.^{2}
$\sqrt{9} = 3$

3 in.

Nearest Estimation Method to find Square Root:
Example: Estimate the square root of 7.

1. Pick two perfect squares closest to the number you want to find the square root of; choose one perfect square greater than the number you want to find the square root of and one perfect square less than the number you want to find the square root of. Two perfect squares below and above 7 are 4 and 9.
2. Since 7 is closer to 9 than it is to 4, then $\sqrt{7}$ must be between $\sqrt{4} = 2$ and $\sqrt{9} = 3$ but closer to $\sqrt{9} = 3$.
3. An estimate around 2.6 to 2.7 would be fine.

Instructor's Script - Comparing and Contrasting
Finding square roots of numbers is not an isolated skill for carpenters. Carpenters must be able to use the Pythagorean Theorem, find the square root of the measurement (which often is not an integer), and then must be able to convert that measurement to feet, inches, and fractional inches. For example, sample problem 1 on page three yields an answer of 18.601 feet. In math class, we might round that to 18.6 feet. A carpenter must be able to convert the decimal part of the answer to inches and fractions of an inch, such as 18' 7 $^{3}/_{16}$".

Common Mistakes Made By Students
Unfamiliar with the calculator –Students who borrow calculators or keep switching between styles and models have to continually determine how to enter the square root of a number. Suggestion: It may be important to show students how to take the square root of 4, using both methods to evaluate which order gives the correct answer of 2. Some calculators require the student to press the number then the square root button and others require the square root button before the number.

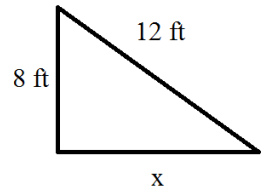
Confusing the $^{x}\sqrt{}$ Button and the $\sqrt{}$ Button – Scientific calculators will have an $^{x}\sqrt{}$ Button and the $\sqrt{}$ Button. The $^{x}\sqrt{}$ Button is used for calculating other roots like a cubed root. Square roots must be found using the $\sqrt{}$ Button.

Estimation – Most errors from estimation without a calculator will come from not knowing perfect squares or not being able to find the middle between other values quickly and easily.

Confusing Square Root and Dividing by Two - Students often think that finding the square root means dividing by two.

CTE Instructor's Extended Discussion
The reason that carpenters use the square root and need to solve the answer to the closest 1/16 of an inch is because the building needs to be built square. Using the Pythagorean Theorem when laying out the foundation plan or floor plan will produce an accurate and square building. Carpenters will also need to use the Pythagorean Theorem to find legs of triangles. For example, will there be enough run to put in a set of stairs?

Example: A 12 ft. stringer will be used to make a set of stairs on a deck. The determining factor of the stair placement is to determine if there is enough run between the deck and the driveway. The stairs will have a max. rise of 8ft. How much of a run is needed to make the stairs?



$$a^2 + b^2 = c^2$$
$$8^2 + b^2 = 12^2$$
$$64 + b^2 = 144$$
$$b^2 = 80$$
$$b = \sqrt{80} = 8.944 \text{ ft.}$$

$$8.944 \text{ ft.}$$
$$0.944 \times 12 = 11.328 \text{ in.}$$
$$0.328 \times 16 = 5.248$$
$$8.944 \text{ ft.} \approx 8\text{ft.} 11\,{}^{5}\!/_{16} \text{ in.}$$

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Problems	Career and Technical Math Concepts	Solutions
1. The diagonal for an $11' \times 15'$ room is $\sqrt{346}$. How many feet is this?		
2. An out of square concrete pad is $6' \times 13'$ with a diagonal measurement of 14'9". For a square concrete pad what should the diagonal measure be? How much out of square is the concrete pad?		
3. Using the Pythagorean Theorem, solve for the diagonal dimension for a footer that measures $25' \times 35'$.		

Problems	Related, Generic Math Concepts	Solutions
4. You want to draw a square box and fill it with 144 1-inch squares, how many inches must each side of your square measure?		
5. A square garden box has an area of 8 square units. What is the length of a side of the square to the nearest tenth?		
6. In celebration of your town's 200th birthday, you are given permission to paint a large image of the town's founder on the side of Town Hall. The town council stipulates that the mural must be square so that it fits in with other artists' work in the bigger picture. They tell you that you will have 140 square feet of "canvas" on which to paint. What is the maximum height that your image can be assuming the founder is not shown leaning diagonally?		

Problems	PA Core Math Look	Solutions
7. Find $\sqrt{324}$. a) 16 b) 17 c) 18 d) 19		
8. Which of the following is the approximate value of $\sqrt{5}$? a) 3.4 b) 2.5 c) 2.2 d) 1.8		
9. Z = $\sqrt{31.25}$ Solve for Z. a) 31.25 b) 5.6 c) 6.6 d) 5.1		

Carpentry (46.0201) T-Chart

Problems	Occupational (Contextual) Math Concepts	Solutions
1.	The diagonal for an $11' \times 15'$ room is $\sqrt{346}$. How many feet is this?	$\sqrt{346} = 18.601'$ $0.601 \text{x} 12 = 7.212"$ $\quad 0.212 \times 16 = 3.392$ 18 ft. $7\ {}^{13}/_{16}$ in.
2.	An out of square concrete pad is $6' \times 13'$ with a diagonal measurement of 14'9". For a square concrete pad what should the diagonal measure be? How much out of square is the concrete pad?	$\sqrt{a^2 + b^2} = \sqrt{6^2 + 13^2} = 14.318$ ft. $0.318 \times 12 = 3.814$ in $\rightarrow$ $0.814 \times 16 = 13.022$ 14 ft. $3\ {}^{13}/_{16}$ in. 14 ft. 9 in. $- 14$ ft. $3\ {}^{13}/_{16}$ in. $= 5\ {}^{13}/_{16}$ in.
3.	Using the Pythagorean Theorem, solve for the diagonal dimension for a footer that measures $25' \times 35'$.	$a^2 + b^2 = c^2 \quad \rightarrow \quad 25^2 + 35^2 = c^2$ $625 + 1225 = c^2$ $1850 = c^2$ $c = \sqrt{1850} = 43.012' = 43'.144" = 43'\ 2/16" = 43'\ 1/8"$
Problems	**Related, Generic Math Concepts**	**Solutions**
4.	You want to draw a square box and fill it with 144 1-inch squares, how many inches must each side of your square measure?	Find the square root of 144 inches. The box should be 12 inches on all sides
5.	A square garden box has an area of 8 square units. What is the length of a side of the square to the nearest tenth?	A square has 4 equal sides so $s^2 = 8$. A side = $\sqrt{8}$ 8 is between 4 and 9, and much closer to 9. So $\sqrt{8}$ is between 2 and 3, much closer to 3. Answer is 2.8 units.
6.	In celebration of your town's 200th birthday, you are given permission to paint a large image of the town's founder on the side of Town Hall. The town council stipulates that the mural must be square so that it fits in with other artists' work in the bigger picture. They tell you that you will have 140 square feet of "canvas" on which to paint. What is the maximum height that your image can be assuming the founder is not shown leaning diagonally?	Find the square root of 140. The painting can be 11.83 feet tall, or **just under** 11' 10" tall. .83' = 9.96"
Problems	**PA Core Math Look**	**Solutions**
7.	Find $\sqrt{324}$. a) 16 b) 17 c) 18 d) 19	c) 18
8.	Which of the following is the approximate value of $\sqrt{5}$? a) 3.4 b) 2.5 c) 2.2 d) 1.8	c) 2.2
9.	$Z = \sqrt{31.25}$ Solve for Z. a) 31.25 b) 5.6 c) 6.6 d) 5.1	b) 5.6