HVAC (47.0201) T-Chart

Determine volume of airflow	=	Apply the properties of rational and irrational numbers to solve real-world or mathematical problems

Program Task: Determine volume of airflow.

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

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

Program Associated Vocabulary:
SQUARE ROOT

Math Associated Vocabulary:
SQUARE ROOT

Program Formulas and Procedures:
HVAC technicians must be able to measure air velocity pressure (P_v) in a duct, then use that pressure reading to calculate the speed at which air is flowing through the duct. An instrument called a Pitot Tube measures P_v in inches of water column (w.c.). The square root of the P_v reading is multiplied by 4,005 (a number carefully derived by the famous 18th century Swiss mathematician, Daniel Bernoulli). Bernoulli's equation states that Velocity (V) in feet per minute is equal to 4,005 multiplied by the square root of the velocity pressure (P_v).

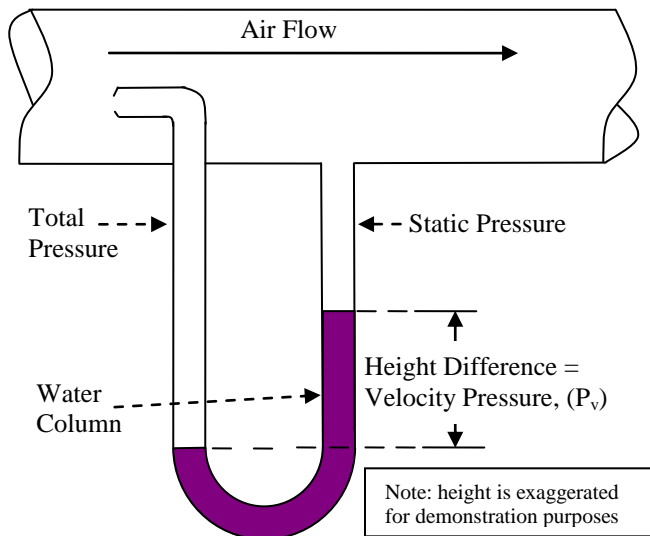$$V = 4005 \times \sqrt{P_v}$$

Example:
A Pitot Tube measurement determines the P_v of an air stream is 0.1" w.c. What is the velocity?

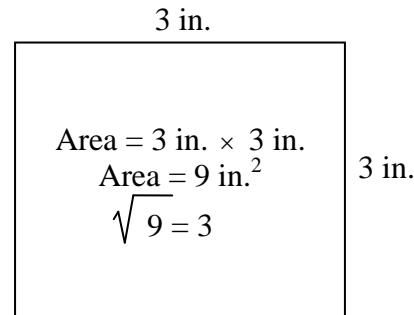$$V = 4005 \times \sqrt{0.1}$$
$$V = 4,005 \times 0.316$$
$$V = 1,266 \text{ ft./min.}$$

Pitot Tube Manometer

Air Flow

Total Pressure

Static Pressure

Height Difference = Velocity Pressure, (P_v)

Water Column

Note: height is exaggerated for demonstration purposes

Formulas and Procedures:
Find Square Roots:

3 in.

Area = 3 in. × 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

When taking the square root of a number, the answer can actually by + or -. So the square root of 4 is actually ±2 because square root answers the question "What number do I multiply by itself to get the number under the root?" In this case "2 times 2 = 4 AND --2 times -2 = 4." In HVAC and most real life applications of square root, the value needed is a measurement so we only concern ourselves with the positive value.

Common Mistakes Made By Students

Unfamiliar with the calculator – Students who borrow calculators or keep switching between styles and models have to know how to take the square root of a number. 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 a $^x\sqrt{}$ 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

In theory, a pitot tube attached to a water tube manometer may be the most reliable and accurate tool for measuring velocity pressure. In practice, however, the very small measurements, often less than 1/10th of an inch in water column, make the water tube nearly impossible to read accurately. Fortunately, a number of high quality electronic measuring devices are available to measure the very small velocity pressures typically found in residential and commercial heating and cooling air ducts. It is just as fortunate for the average technician that modern day pocket calculators are inexpensive and can easily calculate the square roots of very small numbers to at least 3 decimal places.

	Problems	Occupational (Contextual) Math Concepts	Solutions
1.	A Pitot Tube indicates that the P_v of an air stream is 0.08" w.c. What is the velocity of the air flow in feet/min?		
2.	A Pitot Tube indicates that the P_v of an air stream is 0.12" w.c. What is the velocity of the air flow in feet/min?		
3.	A Pitot Tube indicates that the P_v of an air stream is 0.14" w.c. What is the velocity of the air flow in feet/min?		

	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		

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Problems	Occupational (Contextual) Math Concepts	Solutions
1. A Pitot Tube indicates that the P_v of an air stream is 0.08" w.c. What is the velocity of the air flow in feet/min?	$V = 4005 \times \sqrt{0.08}$ $V = 4,005 \times 0.283$ $V = 1,133$ feet/min.	
2. A Pitot Tube indicates that the P_v of an air stream is 0.12" w.c. What is the velocity of the air flow in feet/min?	$V = 4005 \times \sqrt{0.12}$ $V = 4,005 \times 0.346$ $V = 1,387$ feet/min.	
3. A Pitot Tube indicates that the P_v of an air stream is 0.14" w.c. What is the velocity of the air flow in feet/min?	$V = 4005 \times \sqrt{0.14}$ $V = 4,005 \times 0.374$ $V = 1,499$ feet/min.	

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	