HVAC (47.0201) T-Chart

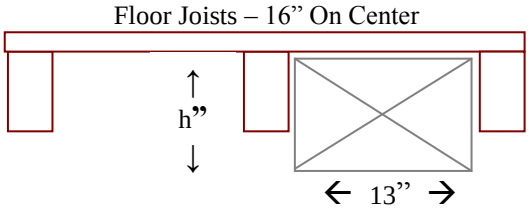
Determine missing dimensions	=	Verify and apply geometric theorems as they relate to geometric figures

Program Task: Determine duct size and layout.

Program Associated Vocabulary:
AREA, WIDTH, HEIGHT, VOLUME, PERIMETER, CIRCUMFERENCE

Program Formulas and Procedures:
When an HVAC professional lays out a duct job, the HVAC technician must consider a number of factors relating to duct size. The duct must have the correct cross sectional area in order to carry the necessary airflow volume at the optimum velocity.

Example:
In order to support a given airflow volume with minimal turbulence and resistance losses, the cross sectional area of the duct must be 208 square inches. Since the duct width is restricted to 13" by the floor joists, what must the height of the duct be?



Note: diagram is not to scale

Area (of rectangle) = $h \times w$

208 $in.^2$ = h inches × 13 inches

$$\frac{208}{13} = \frac{h \times 13}{13}$$

h = 16 inches

PA Core Standard: CC.2.3.HS.A.3

Description: Verify and apply geometric theorems as they relate to geometric figures.

Math Associated Vocabulary:
PERIMETER, CIRCUMFERENCE, AREA, VOLUME, OPPOSITE OPERATIONS, POWERS, ROOTS

Formulas and Procedures:
Given a formula, the student should be able to solve for the missing linear dimension. To do this, the student must use opposite operations.

Opposite Operations	Addition & Subtraction
	Multiplication & Division
	Powers & Roots

Example 1: Find the length of the base of a prism whose volume is 540 cu. ft., whose width is 6 ft. and whose height is 20 ft.

Step 1: Identify the appropriate formula

$V = l \times w \times h$

Step 2: Substitute given values into the formula

$V = l \times w \times h$

$540 = l\,(6)(20)$

Step 3: Solve for the missing variable by using opposite operations

$540 = l(6)(20)$

$540 = l(120)$

$$\frac{540}{120} = \frac{l(120)}{120}$$

Divide both sides by 120 (opposite operation to multiplication).

4.5 ft. = length

Example 2: Find the radius of a cylinder whose height is 4 inches and whose volume is 62.8 cu. in.

Step 1: Identify the appropriate formula

$V = \pi r^2 h$

Step 2: Substitute given values into the formula

$V = \pi r^2 h$

$62.8 = (3.14)r^2(4)$

$62.8 = 12.56r^2$

Step 3: Solve for the missing variable by using opposite operations

$62.8 = 12.56r^2$

$$\frac{62.8}{12.56} = \frac{12.56r^2}{12.56}$$

Divide both sides by 12.56 (opposite operation to multiplication).

$5 = r^2$

$\sqrt{5} = \sqrt{r^2}$

Take the square root of each side (opposite operation to 2nd power).

$2.24 = r$

Instructor's Script - Comparing and Contrasting
The HVAC technician must be able to determine the missing length when given one side of a rectangle and the area. In addition, HVAC technicians must also be able to find the diameter of a circle when given the area of a circle. The math presented in the mathematics classroom is very similar to the math presented in the HVAC classroom.

Common Mistakes Made By Students
Selecting the appropriate formula:

- Students need to identify the shape of the figure and then select the appropriate formula.
- Students often mistakenly use volume formulas when they should be using area formulas.

Applying the opposite operation to solve for the missing dimension:

- Students have difficulty understanding that taking the square root of a number is the opposite of squaring the number.

Using the correct order when using the opposite operation:

- If there is a constant on the side with the variable, the student must add or subtract the constant before dividing by the coefficient.

Example: Find the length of a rectangle whose perimeter is 200 feet and whose width is 12 feet.

$P = 2l + 2w$
$200 = 2l + 2(12)$
$200 = 2l + 24$ ← At this point in the solution process, the student must subtract 24 before dividing by 2!
$200-24 = 2l$
$176 = 2l$
$l = 88$

CTE Instructor's Extended Discussion
Unfortunately, many duct systems are sized incorrectly. The reasons for this vary but the consequences are all too predictable: poor performance, high energy bills, inadequately heated and cooled zones, and unhappy customers. Frequently this is the result of poor math skills and unqualified technicians. Encourage your students to **DO THE MATH**; help them to become professionals!

Other T-Charts in this series address the math needed to determine velocity (FPM) and airflow rate (CFM). If you are teaching airflow and duct work in a series, you may wish to reference the T-Charts that deal with airflow measurements. This T-Chart (page one) example considers the math needed to maintain a cross sectional area when one of the dimensions is beyond the control of the HVAC field engineer.

Problems	Occupational (Contextual) Math Concepts	Solutions
1. You are contracted to leave 1 cord of wood in place after installing a multi-fuel boiler. A cord of wood measures 128 ft.^{3}. The ground space on which you may place the logs is 7' x 3'. If you fill that surface area exactly, how high must the stack of wood be?		
2. You rent an enclosed trailer to carry materials to a jobsite. The vendor states that the trailer's volume measures 360 ft.^{3} of space. You are told that the trailer is 7.5' wide and has 7' interior head room. Will you be able to close the rear door of the trailer after loading 10' lengths of iron pipe inside?		
3. To keep a fluid chiller from short cycling, you must add 50 ft.^{3} of volume to the system's water capacity. You have limited choices for locating a cylindrical tank, and you settle for an area that is a maximum of 3' wide. What size custom tank should you order?		
Problems	**Related, Generic Math Concepts**	**Solutions**
4. What is the radius of a cylinder whose height is 3 in.; the cylinder holds 35 in.^{3} of fluid?		
5. A family would like to build a fence in their backyard to give their dog room to run. They will attach the fence to either side of the house (34 ft.). How long should the fence extend to give the dog 300 ft.^{2} of running room?		
6. A family has 150 ft. of fencing to fence in their garden. If their garden will have a length of 30 ft., how wide can they make it?		
Problems	**PA Core Math Look**	**Solutions**
7. Find the radius of a circle whose circumference is 20 ft.		
8. Find the radius of a circle whose area is 45 in.^{2}.		
9. Find the height of a cylinder whose volume is 300 ft.^{3} and whose radius is 6 ft.		

Problems	Occupational (Contextual) Math Concepts	Solutions
1. You are contracted to leave 1 cord of wood in place after installing a multi-fuel boiler. A cord of wood measures 128 ft.^{3}. The ground space on which you may place the logs is 7' x 3'. If you fill that surface area exactly, how high must the stack of wood be?	Ground space = $7 \times 3 = 21$ ft.^{2} 128 ft.$^3 \div 21$ ft.^{2} = 6 ft. high	
2. You rent an enclosed trailer to carry materials to a jobsite. The vendor states that the trailer's volume measures 360 ft.^{3} of space. You are told that the trailer is 7.5' wide and has 7' interior head room. Will you be able to close the rear door of the trailer after loading 10' lengths of iron pipe inside?	7.5'h $\times$ 7'w = 52.5 ft.^{2} 360 ft.$^3 \div 52.5$ ft.^{2} = 6.86 feet (interior length of trailer) The 10' sections of pipe will not fit in the trailer.	
3. To keep a fluid chiller from short cycling, you must add 50 ft.^{3} of volume to the system's water capacity. You have limited choices for locating a cylindrical tank, and you settle for an area that is a maximum of 3' wide. What size custom tank should you order?	$V = \pi r^2 h$ $50 = 3.14(1.5)^2 h$ $50 = 7.065h$ $\frac{50}{7.065} = \frac{7.065h}{7.065}$ $7.08' = h$ or $7'1''$	
Problems	**Related, Generic Math Concepts**	**Solutions**
4. What is radius of a cylinder whose height is 3 in.; the cylinder holds 35 in.^{3} of fluid?	$V = \pi r^2 h$ $35 = (3.14)r^2(3)$ $35 = 9.42r^2$ $\frac{35}{9.42} = \frac{9.42r^2}{9.42}$ $3.7155 = r^2$ $\sqrt{3.7155} = \sqrt{r^2}$ 1.93in. = r	
5. A family would like to build a fence in their backyard to give their dog room to run. They will attach the fence to either side of the house (34 ft.). How long should the fence extend to give the dog 300 ft.^{2} of running room?	$A = lw$ $300 = l(34)$ $\frac{300}{34} = \frac{l(34)}{34}$ 8.82 ft. = l	
6. A family has 150 ft. of fencing to fence in their garden. If their garden will have a length of 30 ft., how wide can they make it?	$P = 2l + 2w$ $150 = 2(30) + 2w$ $150 = 60 + 2w$ $150 - 60 = 60 - 60 + 2w$ $90 = 2w$ $\frac{90}{2} = \frac{2w}{2}$ 45 ft. = w	
Problems	**PA Core Math Look**	**Solutions**
7. Find the radius of a circle whose circumference is 20 ft.	$C = 2\pi r$ $20 = 2(3.14)r$ $20 = 6.28r$ $\frac{20}{6.28} = \frac{6.28r}{6.28}$ 3.185 ft. = r	
8. Find the radius of a circle whose area is 45 in.^{2}.	$A = \pi r^2$ $45 = 3.14r^2$ $\frac{45}{3.14} = \frac{3.14r^2}{3.14}$ $14.33 = r^2$ $\sqrt{14.33} = \sqrt{r^2}$ 3.79 in. = r	
9. Find the height of a cylinder whose volume is 300 ft.^{3} and whose radius is 6 ft.	$V = \pi r^2 h$ $300 = (3.14)(6)^2 h$ $300 = (3.14)(36)h$ $300 = 113.04h$ $\frac{300}{113.04} = \frac{113.04h}{113.04}$ 2.65 ft. = h	