Automotive Technology (47.0604) T-Chart

pennsylvania
DEPARTMENT OF EDUCATION

Find measurement of piston height	=	**Verify and apply geometric theorems as they relate to geometric figures**

Program Task: Diagnose HVAC systems.

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

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

Program Associated Vocabulary:
STROKE (LENGTH), BORE (DIAMETER), DISPLACEMENT (VOLUME), CIRCUMFERENCE, AREA

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

Program Formulas and Procedures:
Formula to find Stroke of a Cylinder given the Cubic Inch Displacement and the Bore:

$$V = \pi r^2 h$$

$$\frac{V}{\pi r^2} = \frac{\pi r^2 h}{\pi r^2}$$

$$h = \frac{v}{\pi r^2}$$

What is the stroke (h) of a cylinder is the cubic inch displacement (v) of the cylinder is 200in^3 and the bore (d) is 5.0 in?

Bore = 5", cu.in. displacement = 200 in.
Radius (r) = bore $\div 2 = 5 \div 2$ r = 2.5 inches

$$h = \frac{V}{\pi r^2}$$

$$h = \frac{200}{\pi 2.5^2}$$

$$h = \frac{200}{19.63}$$

$$h = 10.2 \text{ (rounded to 10")}$$

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 a cube 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
$$V = l \times w \times h$$
$$540 = l \, (6)(20)$$

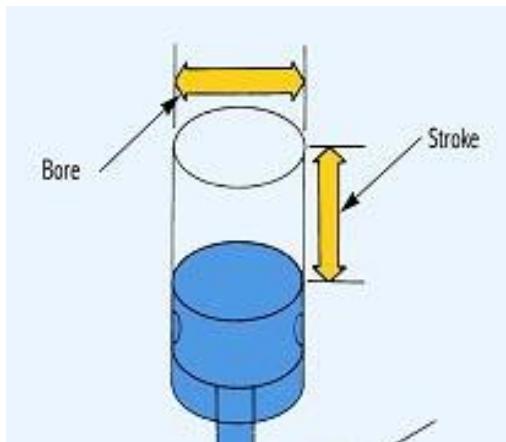Step 3: Solve for the missing variable by using opposite operations
$$540 = l(6)(20)$$
$$540 = l(120)$$
$$\frac{540}{120} = \frac{l(120)}{120}$$

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

$$4.5 \text{ ft.} = \text{length}$$

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
$$V = \pi r^2 h$$
$$62.8 = (3.14)r^2(4)$$
$$62.8 = 12.56 r^2$$

Step 3: Solve for the missing variable by using opposite operations
$$62.8 = 12.56 r^2$$
$$\frac{62.8}{12.56} = \frac{12.56 r^2}{12.56}$$

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

$$5 = r^2$$

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

$$\sqrt{5} = \sqrt{r^2}$$
$$2.24 = r$$

Instructor's Script – Comparing and Contrasting

Formulas in math and for technical applications are usually written in a way that indicates only one value can be found (e.g., if you have the radius of a circle, you can get the area by using $A = \pi r^2$). However, formulas are not only meant to be used in this way.

- Students should understand the full power of a formula by identifying all of the various variables within a formula.
- Charts with missing data can be very useful to have students work through to understand this concept:

Complete chart using: $D = 0.7854(S)(B^2)(N)$, D = engine displacement S = stroke, B = bore, N = # cylinders

D	S	B	N
150 cu. in.	??	3.9"	4
216.5 cu. in.	3.75"	3.5"	??

For more advanced students, have them rearrange formulas without numbers to create "new" formulas:

$$D = 0.7854(S)(B^2)(N) \qquad S = \frac{D}{0.7854B^2N} \quad B = \sqrt{\frac{D}{.7854SN}} \quad N = \frac{D}{0.7854B^2S}$$

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!

CTE Instructor's Extended Discussion

Technical tasks are usually not presented using this model. Therefore, it is important that CTE instructors demonstrate to students how these math concepts link to and are relevant in their technical training and that the math is presented in a way which shows a relationship with the math which CTE students use in their academic school settings.

This T-Chart (left side of page one) example considers the math needed to calculate a measurement/dimension that is beyond the control of the technician, but the auto mechanics student must be able to grasp the concepts of displacement.

This is merely one example in the automotive world which uses this math concept. The standard, however, asks us to find missing lengths in situations where we know the perimeter, circumference, area, or volume. Here are some examples of when you might "find the missing length" in the other categories. Can you add to this list?

1. Given area and one side…
2. Given perimeter and one side…
3. Given circumference…
4. Given volume…

	Problems Career and Technical Math Concepts	Solutions
1.	What is the stroke (h) of a cylinder if the cubic inch displacement (v) of the cylinder = 50 in.^{3} and the bore = 3.75 in.? Use the formula: $h = \dfrac{v}{\pi(r^2)}$	
2.	What is the bore (d) of a cylinder if the cubic inch displacement (v) of the cylinder = 65 in.^{3} & the stroke (h) = 4.5 in.? Use the formula: $r(2) = \sqrt{\dfrac{V}{\pi h}}$ $r(2) = d$	
3.	To improve air conditioning cooling, a TSB (Technical Service Bulletin) states to replace the liquid line with one with twice the area. What diameter line will you need to install if the stock line is a 1/2" diameter? Use the formulas: $a = \pi r^2$ $r = \sqrt{\dfrac{a}{\pi}}$	

	Problems Related, Generic Math Concepts	Solutions
4.	What is the radius of a cylinder whose height is 3 inches; 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 feet). How long should the fence extend to give the dog 300 ft.2 of running room?	
6.	A family has 150 feet of fencing to fence in their rectangular garden. If their garden will have a length of 30 feet, 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. What is the stroke (h) of a cylinder if the cubic inch displacement (v) of the cylinder = 50 in.3 and the bore = 3.75 in.?	$h = \dfrac{v}{\pi r^2}$ $\quad h = \dfrac{50}{\pi 1.875^2}$ $h = 50 \div (\pi \times 3.515625)$ $\;$ h = 4.53 in.	
2. What is the bore (d) of a cylinder if the cubic inch displacement (v) of the cylinder = 65 in.3 & the stroke (h) = 4.5 in..?	$V = \pi r^2 h \quad \dfrac{V}{\pi h} = \dfrac{\pi r^2 h}{\pi h} \quad r^2 = \dfrac{V}{\pi h}$ $r = \sqrt{\dfrac{65}{\pi h}} \quad r = 2.14425 \;\; d = 4.28$	
3. To improve air conditioning cooling, a TSB (Technical Service Bulletin) states to replace the liquid line with one with twice the area. What diameter line will you need to install if the stock line is a 1/2" diameter?	STOCK AREA $\;A = \pi r^2 \;\; A = \pi(.25^2) \;\; A = .19635$ DOUBLE AREA = .3927 $r = \sqrt{\dfrac{a}{\pi}} \quad r = \sqrt{\dfrac{.3927}{\pi}} \quad r = .3534 \qquad d = .7068$ in.	

Problems	Related, Generic Math Concepts	Solutions
4. What is the radius of a cylinder whose height is 3 inches; the cylinder holds 35 in^3 of fluid?	$v = \pi r^2 h \qquad 35 = (3.14)r^2(3) \quad 35 = 9.42r^2$ $\dfrac{35}{9.42} = \dfrac{9.42r^2}{9.42} \quad 3.7155 = r^2$ $\sqrt{3.7155} = \sqrt{r^2} \;\; 1.93 \text{ in.} = r$	
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?	$A = lw \quad 300 = l(34) \quad \dfrac{300}{34} = \dfrac{l(34)}{34} \quad 8.82 \text{ ft} = l$	
6. A family has 150 feet of fencing to fence in their rectangular garden. If their garden will have a length of 30 feet, how wide can they make it?	$P = 2l + 2w \qquad 150 = 2(30) + 2w \quad 150 = 60 + 2w$ $150 - 60 = 60 - 60 + 2w \quad 90 = 2w \qquad \dfrac{90}{2} = \dfrac{2w}{2} \qquad 45 \text{ ft} = w$	

Problems	PA Core Math Look	Solutions
7. Find the radius of a circle whose circumference is 20 ft.	$C = 2\pi r \qquad 20 = 2(3.14)r \qquad 20 = 6.28r$ $\dfrac{20}{6.28} = \dfrac{6.28\,r}{6.28} \quad 3.185 \text{ ft.} = r$	
8. Find the radius of a circle whose area is 45 in^2.	$A = \pi r^2 \qquad 45 = 3.14r^2$ $\dfrac{45}{3.14} = \dfrac{3.14r^2}{3.14} \quad 14.33 = r^2$ $\sqrt{14.33} = \sqrt{r^2} \quad 3.79 \text{ in} = r$	
9. Find the height of a cylinder whose volume is 300 ft.^{3} and whose radius is 6 ft.	$V = \pi r^2 h \qquad 300 = (3.14)(6)^2 h \quad 300 = (3.14)(36)h$ $300 = 113.04h \quad \dfrac{300}{113.04} = \dfrac{113.04h}{113.04} \quad 2.65 \text{ ft.} = h$	