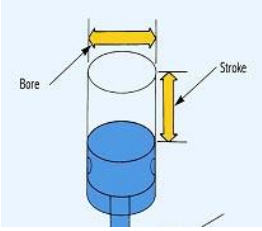
Automotive Technology (47.0604) T-Chart

Describe changes in engine measurement	=	Analyze relationships between two-dimensional and three-dimensional objects

Program Task: Perform precision measurements.

Program Associated Vocabulary:
STROKE, VOLUME, BORE, CUBIC INCH DISPLACEMENT (CID), VOLUME

Program Formulas and Procedures:
To increase horsepower, custom engine building involves increasing internal engine cubic inch displacement without changing the outside dimensions of the engine. This is done by increasing the bore and/or stroke. To increase the bore, metal is "bored" from the cylinder. There are two ways to change the stroke: shorten the length of the piston and/or shorten the length of the piston rod, or use a "stroker" crankshaft, which changes the distance the piston moves up and down.



Example 1:
Step 1: Since a value has not been assigned to the original figure, assign any value to the bore and stroke to solve for the CID. For this example, use a value of three inches for the bore and four inches for the stroke.

$$CID = \frac{bore^2 \pi stroke}{4} \quad CID = \frac{3^2 \pi 4}{4} \quad CID = 28.27 cu.in$$

Step 2: Double the bore and solve for the CID.

$$CID = \frac{bore^2 \pi stroke}{4} \quad CID = \frac{6^2 \pi 4}{4} \quad CID = 113.10 cu.in$$

Step 3: Compare the two CIDs. Did they double also or increase by some other multiplier? Hint: Divide the larger volume by the smaller volume. 113.10 is 4 times larger than 28.27 because 113.10/28.27 = 4

Example 2:
If the diameter of a tire is increased from 15 in. to 30 in., by how much is the area increased?

Step 1: Since values have been assigned to figure, use this formula: Area of a Circle: $A = \pi r^2$

Step 2: Find the area of both figures.

$$A = \pi 7.5^2 \quad A = 176.71 in.sq$$

$$A = \pi 15^2 \quad A = 706.86 in.sq$$

Step 3: Compare the two areas. Did they double also or increase by some other multiplier? Hint: Divide the larger area by the smaller area. 706.86/176.71=4

PA Core Standard: CC.2.3.HS.A.13

Description: Analyze relationships between two-dimensional and three-dimensional objects.

Math Associated Vocabulary:
LINEAR DIMENSION, PERIMETER, CIRCUMFERENCE, AREA, VOLUME, DOUBLE, TRIPLE, CUBIC, SQUARE

Formulas and Procedures:
Students are often asked to evaluate the impact on perimeter, circumference, area, or volume when one of the linear dimensions, such as length, height or radius is increased. Often, the questions involve doubling or multiplying the dimension by a certain value.

In order to solve these problems, students should solve the problem using the original and larger linear dimension and then compare the results.

Example 1*:* If the radius of a circle is doubled, by how much is the area increased?

Step 1: Since a value has not been assigned to the original figure, assign any value to the original circle and solve for the area. For this example, use an arbitrary value of 10 inches for the radius.

$$A = \pi r^2$$

$$A = 3.14(10)(10) = 314 in^2$$

Step 2: Double the radius and solve for the area.

$$A = \pi r^2$$

$$A = 3.14(20)(20) = 1256 in^2$$

Step 3: Compare the two areas. Did they double also or increase by some other multiplier? Hint: Divide the larger area by the smaller area.

1256 is 4 times larger than 314 because 1256/314 = 4

Example 2: If the side of a cube is increased from 3 in. to 6 in., by how much is the volume increased?

Step 1: Since a value has been assigned to the original figure, use this value (3 in.) and solve for the volume.

$V = l \times w \times h$ (the length, width, and height all equal 3 in.)

$$V = 3 \bullet 3 \bullet 3 = 27 in^3$$

Step 2**:** Find the volume of the larger figure.

$$V = 6 \times 6 \times 6 = 216 in^3$$

Step 3: Compare the two volumes. Did they double also or increase by some other multiplier? Hint: Divide the larger area by the smaller area.

216 is 8 times larger than 27 because 216/27 = 8

Instructor's Script – Comparing and Contrasting

The math involved in this lesson contributes to a set of math-related tools that gives students the ability to predict the outcome of changes before actually implementing the change (along with estimation, direct and inverse proportions, and manipulating formulas). For example, students may be able to predict that while an increase in stroke may lead to likewise increase in displacement, an increase in bore would increase the displacement by a factor of 4.

When students rearrange given formulas, have them keep the value that is being changed on the "busy" side of the equation and keep the value observed isolated on the other side.

Example: If a tire's area increases from 314 sq. in. to 628 sq. in., how much did the diameter change?

Since $A = \pi r^2$, then $r = \sqrt{\frac{A}{\pi}}$ $r_1 = \sqrt{\frac{314}{3.14}} = 10$, $d = 20$ $r_2 = \sqrt{\frac{628}{3.14}} = 14.1$, $d = 28.2$

So, as the area doubled, the radius increased from 20 in. to 28.2 in., or by a factor of $\frac{28.2}{20} = 1.41$.

Some students may realize that the impact of a change in a variable within a formula has a lot to do with the position of that variable (numerator, denominator, squared, cubed, etc.).

Common Mistakes Made By Students

Students often do not recognize that values may be substituted into the formulas to evaluate the effects of changing the linear dimensions. For instance, if the problem asks how the volume of a cube is affected if the lengths of the sides are doubled. For this example, the student could use two fictitious values to test, like 2 and 4 or 3 and 6.

CTE Instructor's Extended Discussion

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

Automotive technology service professionals need to carry volume, area, perimeter and other formulas in their heads just as surely as they carry gauges, meters, and hand tools in their belts and boxes. As teachers, our goal is to help our students get to that math skill level.

Problems	Career and Technical Math Concepts	Solutions
1. What will the CID of a V-8, 283 cu.in small block Chevy (B = 3.875 S = 3.00) be if you increase the Stroke to 4.00"? IV = Initial value NV = New Value		
2. You want replace the stock 10" diameter clutch with a 12" diameter competition clutch. By how much will the clutch contact area increase?		
3. An engine keeps overheating. A TSB recommends installing a larger cooling fan to correct the problem. By what will circumference change to if you replace the 14" cooling fan with a 16" fan; by what will the area increase? (circumference, C= πd)		
Problems	**Related, Generic Math Concepts**	**Solutions**
4. A soup company would like to change the design of their cans so they hold more soup. If they triple the radius of the can, by how much will they increase the amount of soup each can will be able to hold?		
5. Jake and Jenny each have a beach ball, but Jenny's ball has twice the diameter of Jake's ball. How many times more volume of air can Jenny's ball hold?		
6. A family decides to extend their garden to make it bigger. It originally had a width of 10 feet and a length of 13 feet. They must keep the length the same, but plan to increase the width of the garden to 12 feet. How much more fencing will they need to enclose the garden?		
Problems	**PA Core Math Look**	**Solutions**
7. By how much does the area of a rectangle increase if the width remains the same but the length is doubled?		
8. The perimeter of a rectangle is 30 feet when the width is 5 feet and the length is 10 feet. If the length is increased to 15 feet and the width remains the same, find the new perimeter.		
9. By how much does the volume of a cylinder increase if the radius remains the same, but the height doubles?		

Problems	Occupational (Contextual) Math Concepts	Solutions
1. What will the CID of a V-8, 283 cu.in small block Chevy (B = 3.875 S = 3.00) be if you increase the Stroke to 4.00"? IV = Initial value NV = New Value		radius = bore ÷ 2 = 3.875 ÷ 2 = 1.9375 CID(IV) = $\frac{1.9375^2\pi 3}{4}$ CID = 8.84 × 8 = 70.72 in.cu. CID(NV) = $\frac{1.9375^2\pi 4}{4}$ CID = 11.79 × 8 = 94.32 in.cu. 94.32 ÷ 70.72 = increased by a factor of 1.33
2. You want replace the stock 10" diameter clutch with a 12" diameter competition clutch. By how much will the clutch contact area increase?		A(IV) = $\pi 5^2$ A = 78.54 in.sq. A(NV) = $\pi 6^2$ A = 113.10 in.sq. An increase by a factor of 113.10/78.54=1.44
3. An engine keeps overheating. A TSB recommends installing a larger cooling fan to correct the problem. By what will circumference change to if you replace the 14" cooling fan with a 16" fan; by what will the area increase? (circumference, C= πd)		C(IV) = $\pi 14$ C = 43.98 in. C(NV) = $\pi 16$ C = 50.26 in. an incease by a factor of 1.14 A(IV) = $\pi 7^2$ A = 153.94 in.sq. A(NV) = $\pi 8^2$ A = 201.06 in.sq. an increase by a factor of 1.31
Problems	**Related, Generic Math Concepts**	**Solutions**
4. A soup company would like to change the design of their cans so they hold more soup. If they triple the radius of the can, by how much will they increase the amount of soup each can will be able to hold? $V = \pi r^2 h$		$V = \pi r^2 h$ Method 1: replace r with 3r (tripled) $V = \pi(3r)^2 h = \pi(9r^2)h$ The volume is nine times larger. Method 2: Compare the volumes using r = 1 and r = 3, h = 1. $V = \pi r^2 h$ $V = (3.14)(1)(1)(1) = 3.14$ $V = \pi r^2 h$ $V = (3.14)(3)(3)(1) = 28.26$ Divide the two values to find the factor by which the volume increases. 28.26 ÷3.14 = 9
5. Jake and Jenny each have a beach ball, but Jenny's ball has twice the diameter of Jake's ball. How many times more volume of air can Jenny's ball hold? $V_1 = \frac{4}{3}\pi r^3$		$V_1 = \frac{4}{3}\pi r^3, V_2 = \frac{4}{3}\pi(2r)^3$ $V_2 = \frac{4}{3}\pi(8r^3)$ Jenny's ball holds 8 times more volume of air.
6. A family decides to extend their garden to make it bigger. It originally had a width of 10 feet and a length of 13 feet. They must keep the length the same, but plan to increase the width of the garden to 12 feet. How much more fencing will they need to enclose the garden?		Original perimeter = 2(10)+2(13)=46 ft. New perimeter = 2(12)+2(13) = 50 ft. They will need 4 more feet of fencing.
Problems	**PA Core Math Look**	**Solutions**
7. By how much does the area of a rectangle increase if the width remains the same but the length is doubled?		$A_1 = lw, A_2 = 2lw$ The area doubles.
8. The perimeter of a rectangle is 30 feet when the width is 5 feet and the length is 10 feet. If the length is increased to 15 feet and the width remains the same, find the new perimeter.		Perimeter = 2(5) + 2(15) = 40 feet.
9. By how much does the volume of a cylinder increase if the radius remains the same, but the height doubles?		If the height doubles, the volume doubles. $V = \pi r^2 h \rightarrow V = \pi r^2(2h)$ $\rightarrow V = 2\pi r^2 h$