

Interpret engineering drawings = Verify and apply theorems involving similarity as they relate to plane figures

Program Task: Interpret engineering drawings.

PA Core Standard: CC.2.3.HS.A.6

Program Associated Vocabulary:
PROPORTIONATE, SCALE

Description: Verify and apply theorems involving similarity as they relate to plane figures.

Math Associated Vocabulary:
CONGRUENT, ANGLES, FIGURES, POLYGONS, SEGMENTS, SIDES, SIMILAR, PROPORTIONAL, RATIO, SOLIDS, SQUARE, LINEAR DIMENSIONS, PRODUCT, MEANS, EXTREMES, CORRESPONDING, REGULAR

Program Formulas and Procedures:
Throughout the machining industry, there is often a need for scaling. Scaling is a proportionate change in size. Understanding scale is important to accurately interpret prints. Prints frequently display parts larger or smaller than actual size to clarify details and sizes.

Formulas and Procedures:
The product of the means is equal to the product of the extremes.

$$\frac{a}{b} = \frac{c}{d} \rightarrow ad = bc$$

Example:
A large die plate needs to be 2” thick, 15” wide, and 72” long. What scale factor should be used so that the length will be 6” on a print?

If two polygons are congruent (\cong), then the corresponding sides and angles are congruent.

The rectangle on the paper will be similar to the actual size rectangle. The interior angles will be equal and the lengths will be proportionate.

If two polygons are similar, then the corresponding angles are congruent and the corresponding side lengths are proportional.

$$\frac{6''}{72''} = \frac{x}{1}$$

$$72x = 6 \rightarrow x = \frac{6}{72}$$

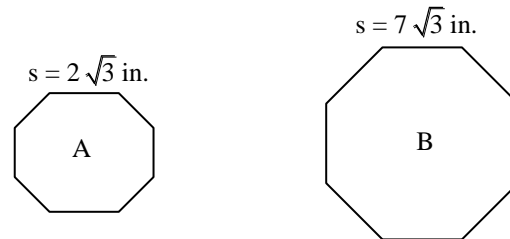
$$x = \frac{1}{12}, \text{ so a } 1/12 \text{ scale would be used}$$

1” on print would represent 12” in real life

If two solids are similar, then the corresponding linear measures are proportional.

If the ratio of the sides of two figures is a:b, then the ratio of the areas of the figures is $a^2:b^2$.

Example: Given the regular octagons, the side lengths and the area of octagon A (57.94 square inches), what is the area of octagon B?



$$\frac{7\sqrt{3}}{2\sqrt{3}} = \frac{7}{2} \quad \text{The ratio of the Octagon B to Octagon A is 7:2.}$$

So the ratio of the areas would be $7^2:2^2$ and the area proportion is:

$$\frac{7^2}{2^2} = \frac{\text{Area}_B}{57.94}$$

$$\frac{49}{4} = \frac{\text{Area}_B}{57.94}$$

$$49 \times 57.94 = 4(\text{Area}_B)$$

$$2839.06 = 4(\text{Area}_B)$$

$$709.77 = \text{Area of Octagon B}$$

Instructor’s Script – Comparing and Contrasting

Similar polygons have applications in many places. From model cars to blueprints to doll houses, there are examples of similar polygons everywhere.

Common Mistakes Made By Students

One mistake students make is writing the vertexes of the polygons in the wrong order. All corresponding sides and angle must match up.

Students sometimes confuse solving a proportion and do not multiply the means and extremes.

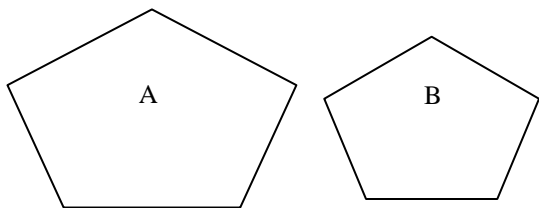
Example 1:

If you are setting up a proportion to convert 3 feet to inches, use the concept: the product of the means is equal to the product of the extremes.

$$\frac{x}{3 \text{ feet}} = \frac{12 \text{ inches}}{1 \text{ foot}}$$

$$x = 36 \text{ inches}$$

Example 2:



Pentagon A and Pentagon B are similar if a side length in Pentagon A is 5 cm, the corresponding side length in Pentagon B is 3 cm, and the area of Pentagon B is 90 square centimeters. What is the area of Pentagon A?

Since the figures are similar the ratio of their area will be $5^2:3^2$.

$$\frac{5^2}{3^2} = \frac{x}{90 \text{ sq. cm.}}$$

$$5^2 (90 \text{ sq. cm.}) = 3^2 x$$

$$2250 \text{ sq. cm} = 9x$$

$$x = 250 \text{ sq. cm}$$

Product of the means equals the product of the extremes.

CTE Instructor’s Extended Discussion

Scale factors on prints are one example of the use of congruent polygons.

Another situation that uses similar polygons also deals with scale. Suppose a prototype model is produced to a smaller size such as $\frac{1}{2}$, or $\frac{1}{4}$, the reciprocal of the scale factor is multiplied by the model sizes to determine actual sizes.

Machine Tool Technology (48.0501) T-Chart

Problems	Career and Technical Math Concepts	Solutions
1. A $\frac{1}{4}$ scale prototype model of a machine uses a $\frac{1}{4}$ " x 2.5" x 3.25" base. What would be the size of the base for the actual machine?		
2. A 40' long conveyor needs to be drawn 10" long on an 8 $\frac{1}{2}$ x 11 print. What scale factor should be used?		
3. A .075 square medical device is shown at a 25:1 scale on an engineering drawing. What is its size on the paper?		
Problems	Related, Generic Math Concepts	Solutions
4. If pentagon ABCDE is similar to pentagon FGHIJ and the scale factor is 2:3, and $BC = 2x + 6$ and $GH = 6$, what is the value of x ?		
5. You are reading a map. You are traveling that on the map is $3\frac{1}{2}$ inches from your current location. If the scale of the map is $\frac{1}{4}$ inch = 5 miles, then how far must you travel to reach your destination?		
6. The area of the base of a square pyramid is 144 square feet. If the height of this pyramid is 8 feet and the height of a similar pyramid is 4 feet, what is the area of the base of this similar pyramid?		
Problems	PA Core Math Look	Solutions
7. Hexagon A and Hexagon B are similar if a side length in Hexagon A is 4 meters, the corresponding side length in Hexagon B is 7 meters, and the area of Hexagon B is 343 square meters. What is the area of Hexagon A?		
8. You want to know the height of a flagpole. The shadow of the flagpole is 10 feet and the shadow of a ruler is 8 inches. How high is the flagpole?		
9. You hired someone to lay ceramic tile in your bathroom 6 months ago. The bathroom dimensions were 6' x 4' and the job cost \$327. You have decided to tile another bathroom with the dimensions 9' x 6'. What is a reasonable cost for the job?		

Problems	Career and Technical Math Concepts	Solutions
1. A ¼ scale prototype model of a machine uses a ¼" x 2.5" x 3.25" base. What would be the size of the base for the actual machine?		1" scale = 4" real life $\frac{1}{4} = \frac{3.25}{x}$ x = 13 inches actual size
2. A 40' long conveyor needs to be drawn 10" long on an 8 ½ x 11 print. What scale factor should be used?		scale $\frac{10"}{40'} = \frac{10"}{480"} = \frac{1}{48}$ 1 : 48 scale would be used
3. A .075 square medical device is shown at a 25:1 scale on an engineering drawing. What is its size on the paper?		This is a situation where the real life device is enlarged on paper. scale $\frac{25}{1} = \frac{x}{.075}$ x = 25(.075) = 1.875"
Problems	Related, Generic Math Concepts	Solutions
4. If pentagon ABCDE is similar to pentagon FGHIJ and the scale factor is 2:3, and BC = 2x and GH = 6, what is the value of x?		$\frac{2}{3} = \frac{2x}{6} \rightarrow 3(2x) = (2)(6) \rightarrow 6x = 12 \rightarrow x = 2$
5. You are reading a map. You are traveling a city that on the map is 3½ inches from your current location. If the scale of the map is ¼ inch = 5 miles, then how far must you travel to reach your destination?		$\frac{1}{4} = \frac{3\frac{1}{2}}{x} \rightarrow \frac{1}{4} x = (3\frac{1}{2})(5) \rightarrow (4) \frac{1}{4} x = 17\frac{1}{2}(4) \rightarrow x = 70$ You must travel 70 miles.
6. The area of the base of a square pyramid is 144 square feet. If the height of this pyramid is 8 feet and the height of a similar pyramid is 4 feet, what is the area of the base of this similar pyramid?		Since the base is a square, the side is $\sqrt{144}$ or 12. We can set up the proportion as the height to the side length. $\frac{8}{12} = \frac{4}{x} \rightarrow 8x = 48 \rightarrow x = 6$ feet Since the side length is 6, the area of the base is 36 sq. feet.
Problems	PA Core Math Look	Solutions
7. Hexagon A and Hexagon B are similar if a side length in Hexagon A is 4 meters, the corresponding side length in Hexagon B is 7 meters, and the area of Hexagon B is 343 square meters. What is the area of Hexagon A?		$\frac{4^2}{7^2} = \frac{x}{343 \text{ sq. m.}}$ 49x = 5488 x = 112 The area of Hexagon A is 112 square meters.
8. You want to know the height of a flagpole. The shadow of the flagpole is 10 feet and the shadow of a ruler is 8 inches. How high is the flagpole?		$\frac{h}{10'} = \frac{1'}{8"} \quad \text{First convert 8" to feet, } \frac{8"}{12"} = \frac{2}{3}$ $\frac{h}{10'} = \frac{1'}{2\frac{2}{3}}$ 2/3 h = 10 h = (10 x 3)/2 h = 15' The height of the flagpole is 15'.
9. You hired someone to lay ceramic tile in your bathroom 6 months ago. The bathroom dimensions were 6' x 4' and the job cost \$327. You have decided to tile another bathroom with the dimensions 9' x 6'. What is a reasonable cost for the job?		Since the figures are both rectangles and the sides are proportional, they are similar. The ratio of the sides is 2:3 and the ratio of the areas is 4:9. $\frac{4}{9} = \frac{\$317}{x} \rightarrow 4x = 2853 \rightarrow x = \713.25 A reasonable cost for the job is \$713.25.