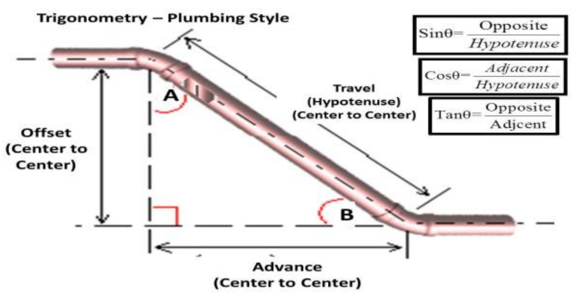
Plumbing and Heating (46.0503) T-Chart

Calculating the travel (length of pipe) needed	=	Apply trigonometric ratios to solve problems involving right triangles

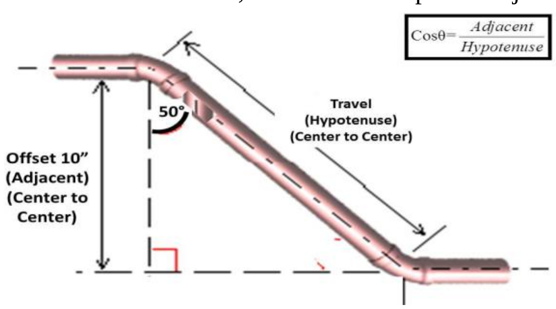
Program Task: Describe the process used by plumbing professionals to calculate the length of travel of a diagonal piping circuit. Many professionals will know the length of run needed as well as the offset (height). Plumbers will need to know how to calculate the travel in order to purchase the correct pipe length that will allow proper fitting of piping.

Program Associated Vocabulary
OFFSET, TRAVEL, HYPOTENUSE, DEGREE, RATIOS, PIPE SIZING, ADVANCE

Program Formulas and Procedures
Formulas for pipe layouts and sizing look similar to that of the PA Core Standard procedure. Most of the time you will measure for the offset and solve for the travel. If you know Angle A and the offset, you could use Cosine to solve for the travel. If you know Angle B and offset, you could use Sine to solve for the travel.



<u>Example:</u> A plumbing technician travels to a job site and obtains measurements that he diagrams on the drawing below. The technician needs to find the length of the pipe between the two elbows, in order to complete the job.



<u>Step 1:</u> Determine the formula that you need to solve for the travel. COSINE
<u>Given:</u> 50° angle and the offset (adjacent side)
<u>Solve:</u> Travel (Hypotenuse)

Step 2: Set up the formula $COS\,(50^o) = \frac{10"}{x}$

Step 3: Solve for the travel

$$COS\,(50^o)\cancel{x} = (x)\frac{10"}{\cancel{x}} \rightarrow \frac{\cancel{COS\,(50^o)}\,x}{\cancel{COS\,(50^o)}} = \frac{10"}{COS\,(50^o)}$$

$$x \approx 15.55 \approx 15\,\frac{9}{16}$$

PA Core Standard: CC.2.3.HS.A.7

Description: Apply trigonometric ratios to solve right triangles in applied problems.

Math Associated Vocabulary
ANGLE, RIGHT TRIANGLE, TRIGONOMETRIC RATIOS, INVERSE TRIGONOMETRIC RATIOS, RECTANGLE RULES

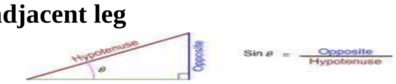
Formulas and Procedures

- A right angle is 90 degrees
- A right triangle has one right angle
- Ask students to find right triangles within the classroom or to think of other real-life examples.
- Legs are sides next to right angle; hypotenuse is the side opposite the right angle and is also the longest side.
- Draw a right triangle on the board. Have students draw it in their notes. Have them identify the legs and the hypotenuse in their notes. Show the answer on the board so they can check their work.
- Opposite sides of a rectangle are equal.

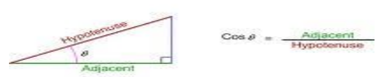
<u>SOH CAH TOA</u>
<u>Sine of the angle</u> = length of opposite leg divided by length of hypotenuse

<u>Cosine of the angle</u> = length of adjacent leg divided by length of hypotenuse

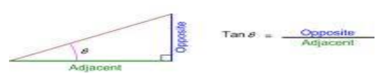
<u>Tangent of the</u> angle = length of opposite leg divided by length of adjacent leg



SOH



CAH



TOA

<u>Example:</u>

Find the angle of a right triangle with an adjacent side of 15, and an opposite side of 25.

Step 1: Determine the operation. Tan = Opposite/Adjacent

Step 2: Since you are looking for the angle, it is an inverse.

Step 3: Substitute values and solve: $Tan^{-1}(25/15) \approx 59^0$

Teacher's Script – Trigonometric Ratios and Real World Applications

Many students find it difficult to find application for their academic math. Plumbing has great trigonometric and geometric applications. The key to understanding and solving these problems is in setting up the problems correctly. It is important in mathematics to stress drawing a picture or diagram and writing out the steps for the procedure.

If you look at the example above, the pipe diagram is drawn so that a distinct triangle is evident. Students can then fill in the sides that will allow them to “see” which formula they need to solve for the missing part of the equation.

Common Mistakes Made By Students

Calculator settings

- Make sure that the mode of the calculator is set to the correct unit for the angle measurements being used (probably degree mode rather than radian mode)
- Enter trig functions in some (most graphing calculators) in the order written.
- In some calculators, the angle is entered before the trig function.
- When calculating angles, generally use the 2nd or shift key with the trig functions to obtain the inverse trig functions
- Since calculators follow the order of operations, when entering complex fractions into the calculator, use parenthesis around the numerator and the denominator, or calculate each separately before dividing.

Trig Errors

- Make sure the correct formula is chosen. Discuss which angle you are looking for and what the different sides mean.
- Make sure rounding of angles is allowed or a discussion on converting decimals to minutes and seconds is necessary.

Drawing discrepancies

- Make sure that an accurate drawing is made and the parts and sides are correct. Knowing what side is opposite and adjacent are concepts students have trouble understanding.
- Some ELL students will need to learn the meaning of the word “adjacent”. We as educators sometimes take vocabulary knowledge for granted.

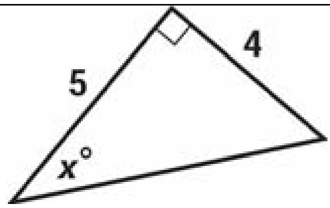
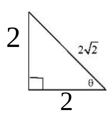
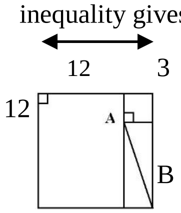
Lab Teacher's Extended Discussion

Pipe fitting and travel are integral parts of the plumbing trade. A plumbing professional needs to be fluent in solving for these problems. If a technician cannot solve these equations quickly and accurately, money will be lost. Not only money, but also an incorrect cutting of materials occurs which can jeopardize the project and can lead to incorrect sizing of pipes.

Another application of this concept is in the reading of specs and blueprints. Students need to be aware that blueprints are not always correct. If you have a good understanding of trigonometry, you can be aware when certain measurements are correct or incorrect.

Many students feel that trigonometry is difficult. If you break it down in steps and draw the pictures, students can solve these equations easily.

Plumbing and Heating (46.0503) T-Chart

Problems Occupational (Contextual) Math Concepts	Solutions
1. Given an offset of 36” and an advance of 48”, what are the two interior angle measurements?	
2. Calculate the travel if you are given an 18” advance and a 22.5° adjacent angle to the advance.	
3. A plumbing inspector reads the blueprints and notices that it says that the diagonal (C to C) is 6”, the offset is 4.25’; therefore, the included angle is 45.9°. Is this a correct angle measurement? Prove your answer.	
Problems Related, Generic Math Concepts	**Solutions**
4. $\tan^{-1} .53 =$ _______	
5. $\tan x = \frac{7}{8}$, $x =$ _______	
6.  $x =$ _______	
Problems PA Core Math Look	**Solutions**
7. Consider the following right triangle. Which of the following statements is correct?  A) $\sin\theta < \cos\theta$ B) $\sin\theta > \cos\theta$ C) $\sin\theta = \cos\theta$ D) $\sin\theta = 2$	
8. Using the drawing, including the 2 squares, which inequality gives the **best approximation** to AB?  A) 9 < AB < 10 B) 11 < AB < 12 C) 10 < AB < 11 D) 9 < AB < 12	
9. If a right triangle has a SAS of 6”, 40°, and 8” (hypotenuse), what is the measurement of the other angle (y) and the other side (x)?	

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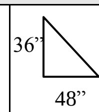
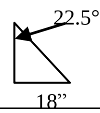
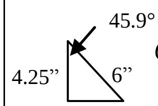
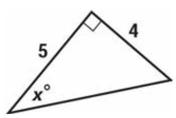
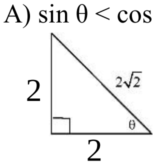
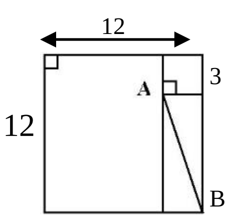
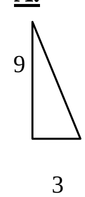
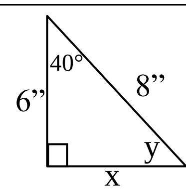
Problems	Occupational (Contextual) Math Concepts Solutions
1. Given an offset of 36" and an advance of 48", what are the two interior angle measurements?	 $Tan^{-1}(\frac{36}{48}) = 36.9^o$ $180^0 - 36.9^o - 90^0 = 53.1^o$
2. Calculate the travel if you are given an 18" advance and a 22.5° adjacent angle to the advance.	 SIN(22.5)=$\frac{18}{x}$ $\rightarrow$ SIN(22.5) x=18 $\rightarrow$ x = $\frac{18}{\text{Sin}(22.50)}$ = 47.04"
3. A plumbing inspector reads the blueprints and notices that it says that the diagonal (C to C) is 6", the offset is 4.25'; therefore, the included angle is 45.9°. Is this a correct angle measurement? Prove your answer.	 $Cos(45.9^0) = \frac{4.25}{6} \rightarrow .696 \neq .708$ *It is not the correct angle.* $Cos^{-1}(\frac{4.25}{6}) = 44.9^0$ *Correct angle.*

Problems	Related, Generic Math Concepts Solutions
4. $\tan^{-1} .53$ = _______ (Rounded to the nearest tenth.)	27.9° (**<u>In TI-30 Calc:</u>** 2nd Key ► Tan ► .53 ► =)
5. tan x = ⅞, x = _______(Rounded to the nearest tenth)	41.2° (**<u>In TI-30 Calc:</u>** 2nd Key ► Tan ► .7/8 ► =)
6.  x = ____ Round to tenth	38.7° Determine Trig Formula: Inverse TAN = $^{Opp}/_{Adj}$ $\text{Tan}^{-1}(^4/_5) = 38.7^0$

Problems	PA Core Math Look Solutions
7. Consider the following right triangle. Which of the following statements is correct? A) sin θ < cos θ  B) sin θ > cos θ C) sin θ = cos θ D) sin θ = 2	**<u>C.</u>** Set up formulas and compare. $Sin\theta = \frac{Opp}{Hyp} = \frac{2}{2\sqrt{2}}$ $Cos\theta = \frac{Adj}{Hyp} = \frac{2}{2\sqrt{2}}$
8. Using the drawing, including the 2 squares, which inequality gives the **best approximation** to AB?  A) 9 < AB < 10 B) 11 < AB < 12 C) 10 < AB < 11 D) 9 < AB < 12	**<u>A.</u>**  Step 1: Determine that all sides of small square are 3 and all sides of the large sq. are 12. Step 2: Pull triangle out and label sides. The long side of the triangle is 12 -3 = 9 Step 3: $\text{Tan}^{-1}(9/3) \approx 71.6^0$ Step 4: Sin 71.6° = 9/Hypotenuse Hypotenuse = 9/Sin $71.6^0 \approx$ **<u>9.5 (A.)</u>** *** Pythagorean Theorem could also be used
9. If a right triangle has a SAS of 6", 40°, and 8" (hypotenuse), what is the measurement of the other angle(y) and the other side (x)?	 Step 1: Solve for Angle y. 40°+90°+y° =180° 130° +y° = 180° y = 50° Step 2: Choose a trig formula. $SIN\theta = \frac{opposite}{hypotenuse} \rightarrow SIN\,40^0 = \frac{x}{8} \rightarrow SIN\,40^0(8) = x \rightarrow x \approx 5.14"$