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Trigono...
Lesson

Lesson 9.3/9.4

Trigonometry

Workbook pages 145-147 and 155-158

Content Objective

Students will solve problems using the trigonometric ratios and inverse trigonometric ratios for acute angles.

Content Objective

Students will solve real-world problems using the trigonometric ratios and their inverses.



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Florida's B.E.S.T. Standards for Mathematics

MA.912.T.1.1

Define trigonometric ratios for acute angles in right triangles.

MA.912.T.1.2

Solve mathematical and real-world problems involving right triangles using trigonometric ratios and the Pythagorean Theorem.

Learn

Trigonometry

The word **trigonometry** comes from the Greek terms *trigon*, meaning triangle, and *metron*, meaning measure. So the study of trigonometry involves triangle measurement. A **trigonometric ratio** is a ratio of the lengths of two sides of a right triangle.

The names of the three most common trigonometric ratios are given on the next few slides.



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Learn

Trigonometry

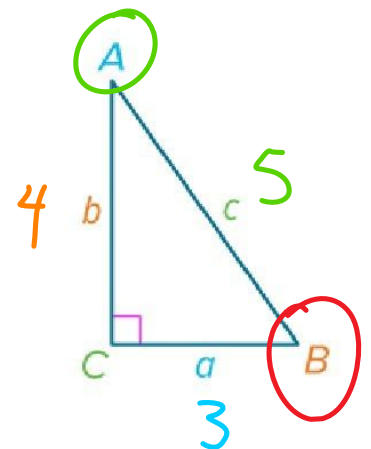
Key Concept: Trigonometric Ratios

Sine: If $\triangle ABC$ is a right triangle, then the sine of each acute angle in $\triangle ABC$ is the ratio of the length of the leg opposite that angle (opp) to the length of the hypotenuse (hyp).

0.01

$$\sin A = \frac{3_{\text{opp}}}{5_{\text{hyp}}} \text{ or } \frac{a}{c}; \sin B = \frac{4_{\text{opp}}}{5_{\text{hyp}}} \text{ or } \frac{b}{c}$$

0.6



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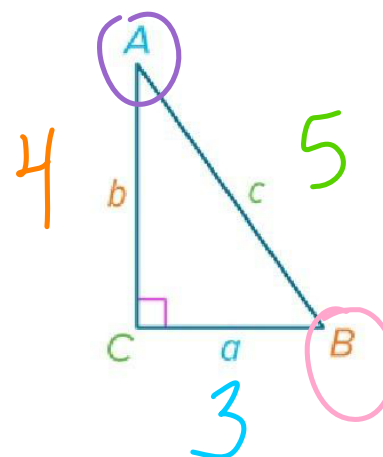
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Trigonometry

Cosine: If $\triangle ABC$ is a right triangle, then the cosine of each acute angle in $\triangle ABC$ is the ratio of the length of the leg adjacent to that angle (adj) to the length of the hypotenuse (hyp).

$$\cos A = \frac{\text{adj}}{\text{hyp}} \text{ or } \frac{b}{c}; \cos B = \frac{\text{adj}}{\text{hyp}} \text{ or } \frac{a}{c}$$

Handwritten annotations: For $\cos A$, 'b' is written as 4 and 'c' as 5. For $\cos B$, 'a' is written as 3 and 'c' as 5.



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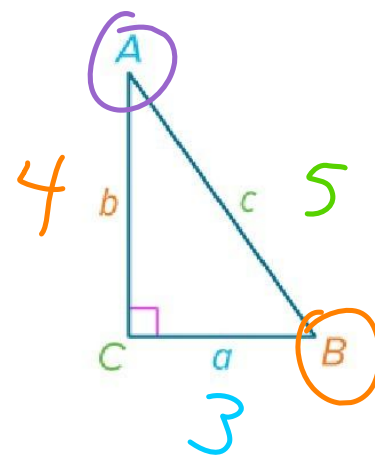


Learn Trigonometry

Tangent: If $\triangle ABC$ is a right triangle, then the tangent of each acute angle in $\triangle ABC$ is the ratio of the length of the leg opposite that angle (opp) to the length of the leg adjacent to that angle (adj).

$$\tan A = \frac{\text{opp}}{\text{adj}} \text{ or } \frac{a}{b}; \tan B = \frac{\text{opp}}{\text{adj}} \text{ or } \frac{b}{a}$$

Handwritten annotations: For $\tan A$, 'a' is written as 3 and 'b' as 4. For $\tan B$, 'b' is written as 4 and 'a' as 3.



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Example 1 Find Trigonometric Ratios

Find $\sin J$, $\cos J$, $\tan J$, $\sin K$, $\cos K$, and $\tan K$. Express each ratio as a fraction and as a decimal to the nearest hundredth.



S

$$\sin J = \frac{\text{opp}}{\text{hyp}} = \frac{5}{13}$$

$$\tan J = \frac{\text{Adj}}{\text{Opp}} = \frac{12}{5}$$

$$\cos J = \frac{\text{Adj}}{\text{Hyp}} = \frac{12}{13}$$



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Example 1

Find Trigonometric Ratios

Check

SOH CAH TOA

Find $\sin A$, $\cos A$, $\tan A$, $\sin C$, $\cos C$, and $\tan C$.

Express each ratio as a fraction and as a decimal to the nearest hundredth, if necessary.

$$\sin = \frac{\text{opp}}{\text{hyp}}$$

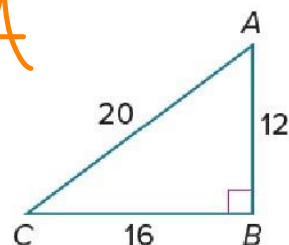
$$\tan = \frac{\text{opp}}{\text{adj}}$$

$$\cos = \frac{\text{adj}}{\text{hyp}}$$

$$\sin C = \frac{12}{20} = \frac{3}{5}$$

$$\cos C = \frac{16}{20} = \frac{4}{5} = 0.8$$

$$\tan A = \frac{16}{12} = \frac{4}{3} = 1.3$$



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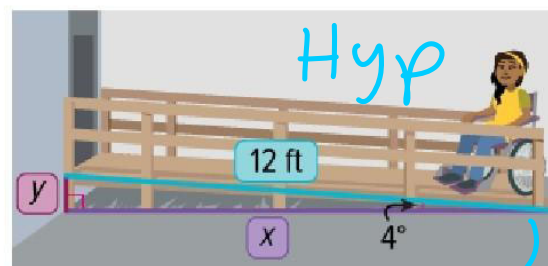


$$\tan C = \frac{12}{16} = \frac{3}{4} = 0.75$$

Example 3

Estimate Measures by Using Trigonometry

ACCESSIBILITY Mathias builds a ramp so his sister can access the back door of their house. The 12-foot ramp to the house slopes upward from the ground at a 4° angle. What is the horizontal distance between the foot of the ramp and the house?



$$\cos 4 = \frac{x}{12}$$

Adj ← cos

11 a 7



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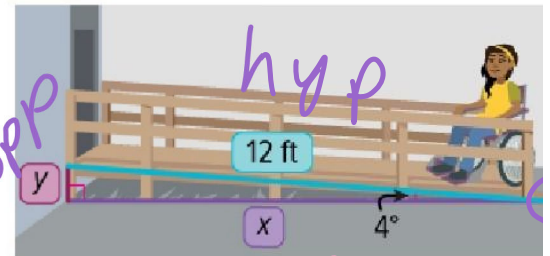


$$11.7 + 12(\cos 4) = x$$

Example 3

Estimate Measures by Using Trigonometry

ACCESSIBILITY Mathias builds a ramp so his sister can access the back door of their house. The 12-foot ramp to the house slopes upward from the ground at a 4° angle. What is the height of the ramp?



$$12(\sin 4 = \frac{y}{12})$$

$$12(\sin 4) = \frac{y}{12}$$

$$0.84$$

$$11.97$$



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Learn

Inverse Trigonometric Ratios

Key Concept: Inverse Trigonometric Ratios

Inverse Sine	Inverse Cosine	Inverse Tangent
Words		
If $\angle A$ is an acute angle and the sine of A is x , then the inverse sine of x is the measure of $\angle A$.	If $\angle A$ is an acute angle and the cosine of A is x , then the inverse cosine of x is the measure of $\angle A$.	If $\angle A$ is an acute angle and the tangent of A is x , then the inverse tangent of x is the measure of $\angle A$.
Symbols		
If $\sin A = x$, then $\sin^{-1}x = m\angle A$.	If $\cos A = x$, then $\cos^{-1}x = m\angle A$.	If $\tan A = x$, then $\tan^{-1}x = m\angle A$.

Find angle



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Example 4

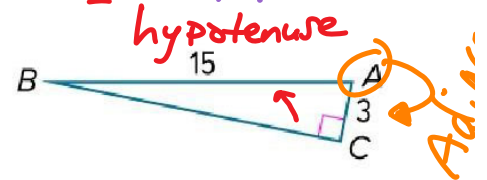
Find Angle Measures by Using Inverse Trigonometric Ratios

SOH CAH TOA

Use a calculator to find $m\angle A$ to the nearest tenth.

78.5°

$$\cos^{-1} = \frac{\text{Adj}}{\text{Hyp}} \frac{3}{15}$$



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Example 4

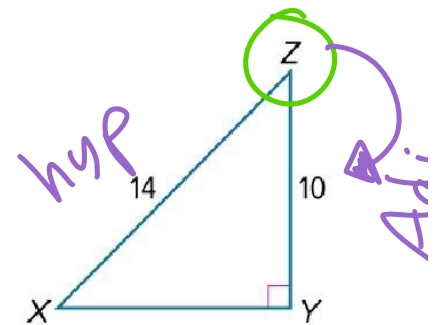
Find Angle Measures by Using Inverse Trigonometric Ratios

SOH CAH TOA

Check

Use a calculator to find $m\angle Z$ to the nearest tenth.

$$\cos^{-1} = \frac{\text{Adj}}{\text{Hyp}} \frac{10}{14}$$



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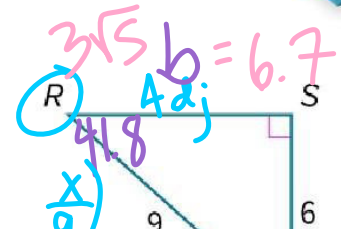


Example 5

Solve a Right Triangle

SOH CAH TOA

Solve the right triangle. Round side and angle measures to the nearest tenth.



$$\cos^{-1} = \frac{\text{Adj}}{\text{Hyp}} \quad \frac{6}{9} = 48.2 \quad (\cos 41.8 = \frac{1}{9})$$

$$\sin^{-1} = \frac{\text{opp}}{\text{hyp}} \quad \frac{6}{9} = 41.8$$

$$c^2 = a^2 + b^2$$

$$9^2 = 6^2 + b^2$$

$$81 = 36 + b^2$$

$$45 = b^2$$

$$b = \sqrt{45}$$



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Example 5

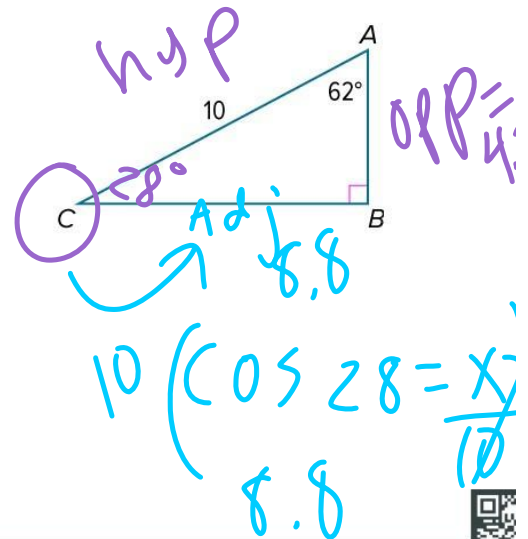
Solve a Right Triangle

Check

Solve the right triangle by finding $m\angle C$, AB , and BC . Round side and angle measures to the nearest tenth.

$$10 (\sin 28 = \frac{x}{10})$$

$$4.7 = x$$



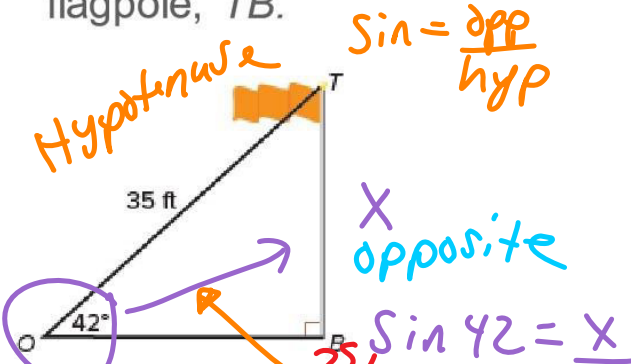
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Solve. Round answers to the nearest tenth.

- Find the height of the flagpole, TB .



- Find the width of the river, w .





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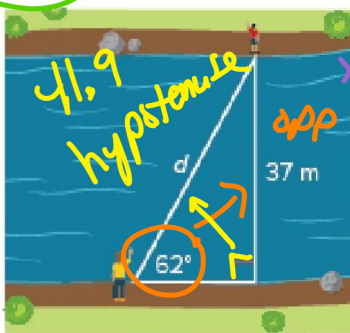
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Solve. Round answers to the nearest tenth.

3. What is the distance between the two people on opposite sides of the river?

SOH CAH TOA



$$\begin{aligned} \sin 62 &= \frac{37}{x} \\ x(\sin 62) &= \frac{37}{(\sin 62)} \\ x &= 41.9 \end{aligned}$$

4. A 20-foot ladder leaning against a wall makes a 50° angle between the ground and the ladder. How far up the wall does the ladder go?



$$\begin{aligned} \sin &= \frac{\text{opp}}{\text{hyp}} \\ 20(\sin 50) &= \frac{x}{20} \\ 15.3 &= x \end{aligned}$$



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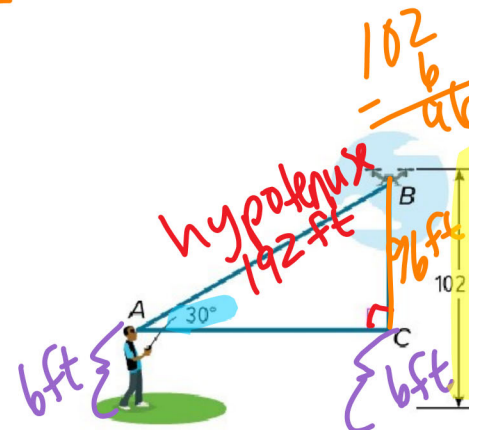
Example 1

Angle of Elevation

SOH CAH TOA

DRONES Rakeem is flying his drone at the park. He spots the drone at an **angle of elevation** that he estimates to be 30° . The remote control tells Rakeem that his drone is **102 feet above the ground**. If Rakeem is **6 feet tall**, how far is he from the drone to the nearest foot?

$$\begin{aligned} \sin 30 &= \frac{96}{x} \\ x(\sin 30) &= \frac{96}{\sin 30} \\ x &= 192 \end{aligned}$$



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Example 1 Angle of Elevation

Check

SEARCH AND RESCUE A flare is shot vertically into the air approximately 200 meters from base camp. The angle of elevation from base camp to the maximum height of the flare is 35° . The group at base camp needs to know the altitude of the flare. What is the maximum height of the flare to the nearest meter?

height opposite

200 (Tan 35 = $\frac{x}{200}$) $\frac{opp}{adj}$

200 (tan 35) = x

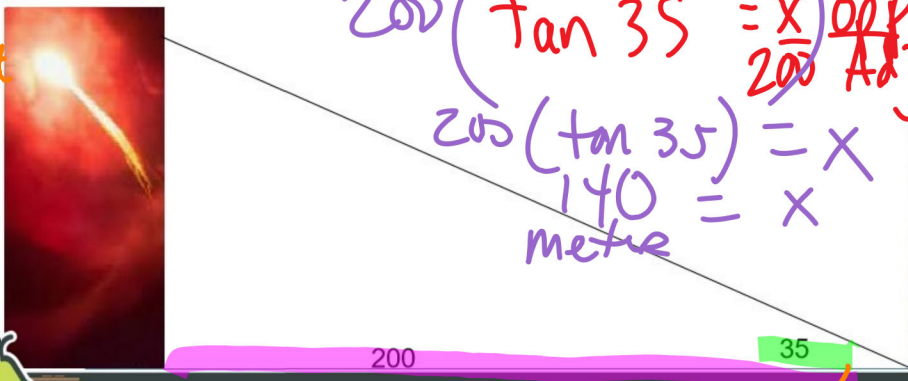
140 = x

metre

SOH CAH TOA

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Example 2

Angle of Depression

SIGHTSEEING Cottonwood, Idaho's Dog Bark Park Inn is a popular tourist attraction featuring a hotel in the shape of a 30-foot wood-carved beagle. Pedro looks out the window 30 feet from the ground and spots a fire hydrant on the ground at an estimated angle of depression of 40° . What is the horizontal distance from Pedro to the hydrant to the nearest foot?

SOH CAH TOA

alternate interior angles =

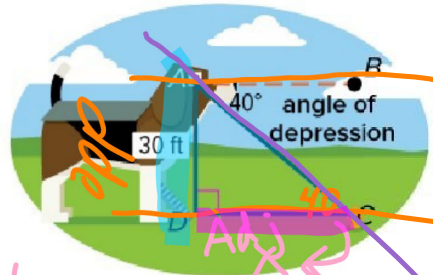
x (Tan 40 = $\frac{30}{x}$) $\frac{opp}{adj}$

x (tan 40) = 30

x = 36 ft

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Example 2

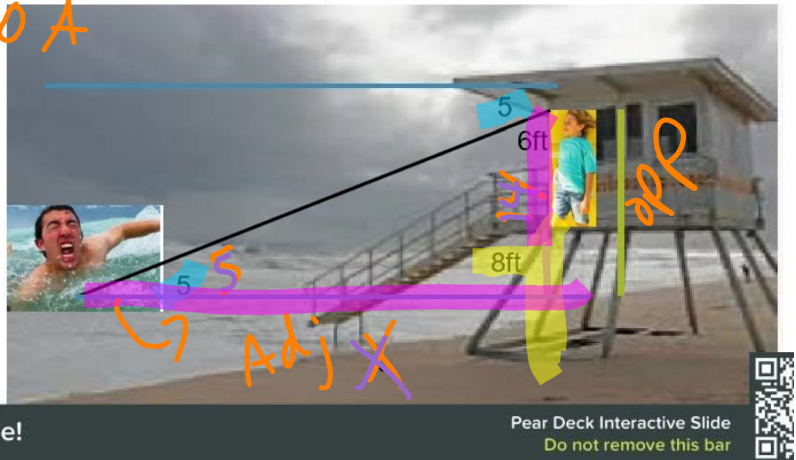
Angle of Depression

Check

LIFEGUARDING Braylen stands on an 8-foot platform and sights a swimmer at an angle of depression of 5° . If Braylen is 6 feet tall, how

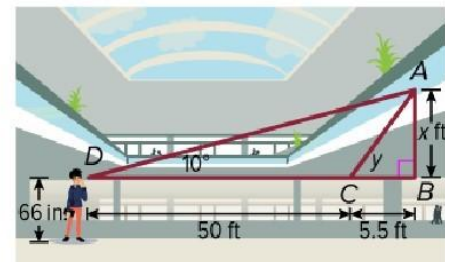
swimmer at an angle of depression of 5° . If Braylen is 6 feet tall, how far away is the swimmer from the base of the platform to the nearest foot? **SOH CAH TOA**

$$\begin{aligned} \times (\tan 5 &= \frac{14}{x}) \times \text{opp} \\ &\text{Adj.} \\ \times (\tan 5) &= \frac{14}{x} \\ \times &= 160 \text{ ft} \end{aligned}$$



Example 3

Use Two Angles of Elevation or Depression
MALL Wei is estimating the height of the second floor in the mall. She sights the second floor at a 10° angle of elevation. She then steps forward 50 feet, until she is 5.5 feet from the wall and sights the second floor again. If Wei's line of sight is 66 inches above the ground, at what angle of elevation does she sight the second floor? Remember to determine the height to the top of the second floor.

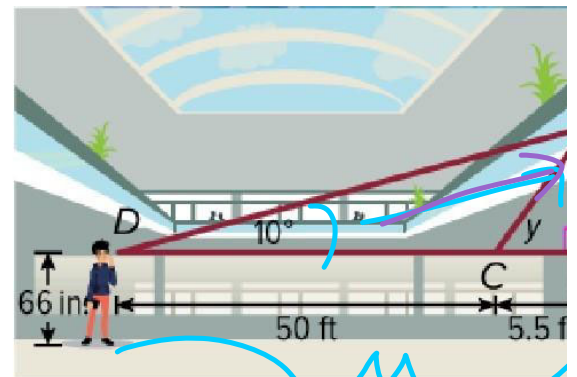


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$$\begin{aligned} \text{SOH CAH } \textcircled{\text{TOA}} \\ 55.5 (\tan 10) &= \frac{x}{55.5} \text{ opp} \\ &\text{Adj.} \\ 55.5 (\tan 10) &= x \end{aligned}$$



55.5

$$9.8 = x$$

Adj



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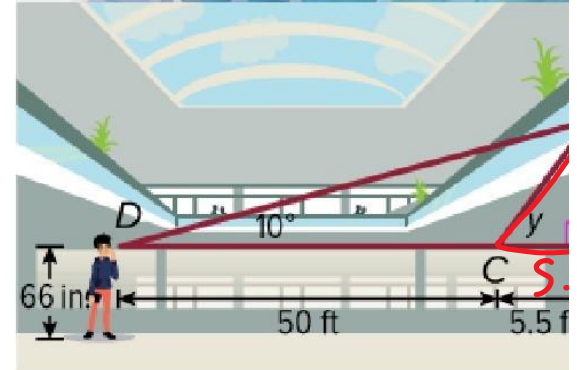
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SOH CAH TOA

$$\tan^{-1} = \frac{9.8}{5.5}$$

Nearest degree 61°



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Example 3

Use Two Angles of Elevation or Depression

Check

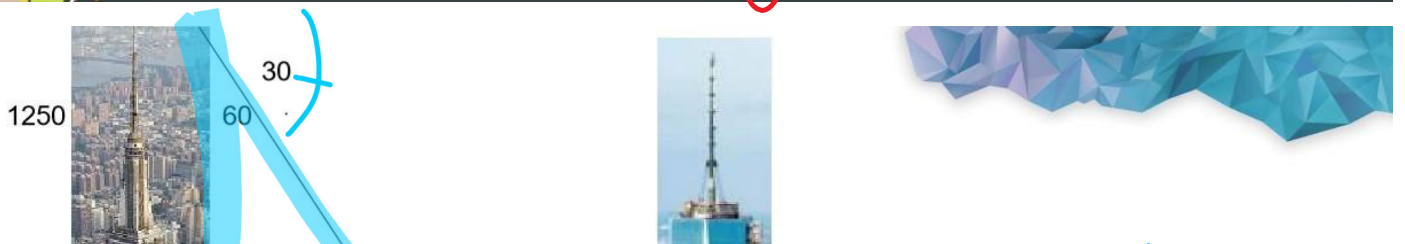
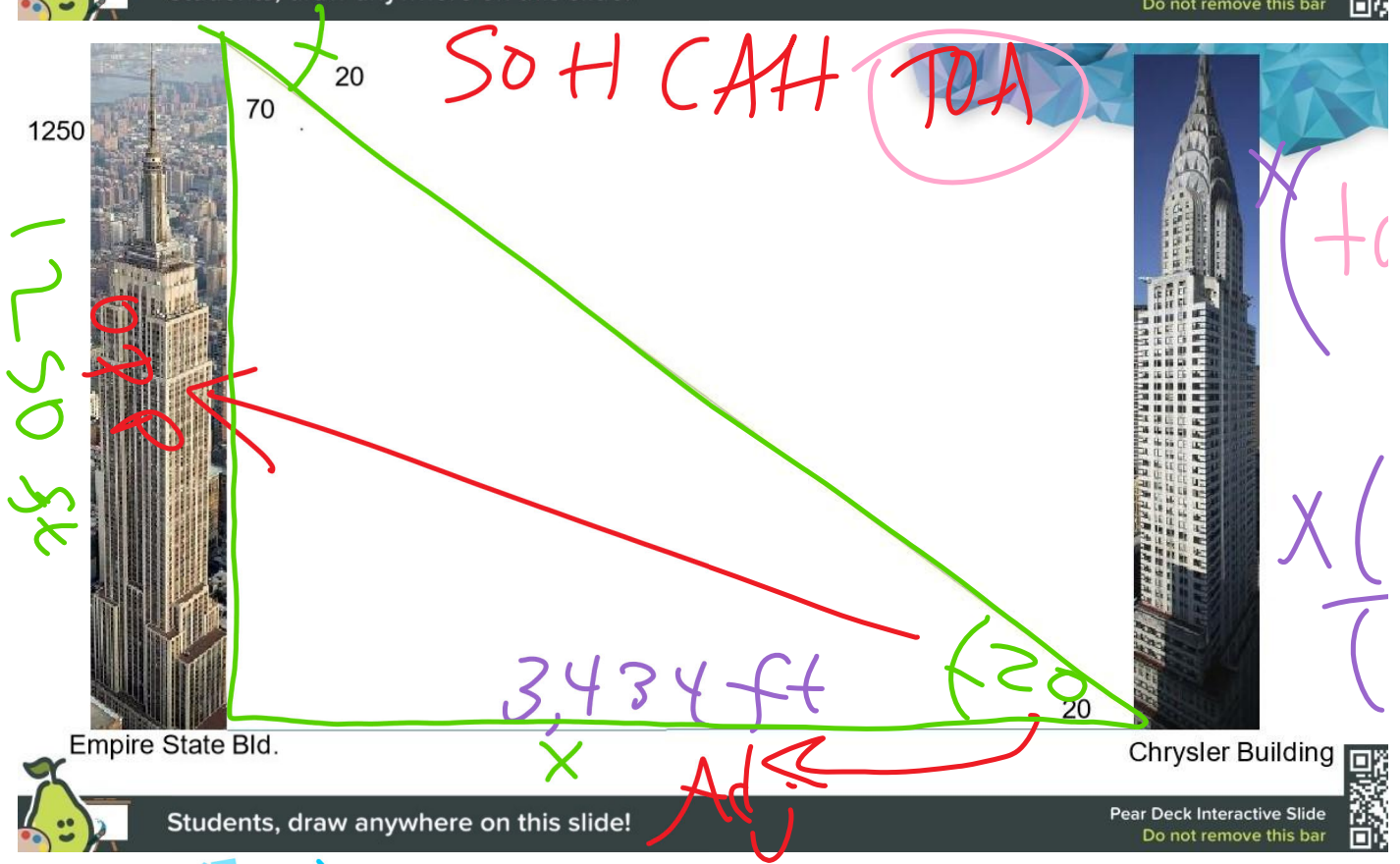
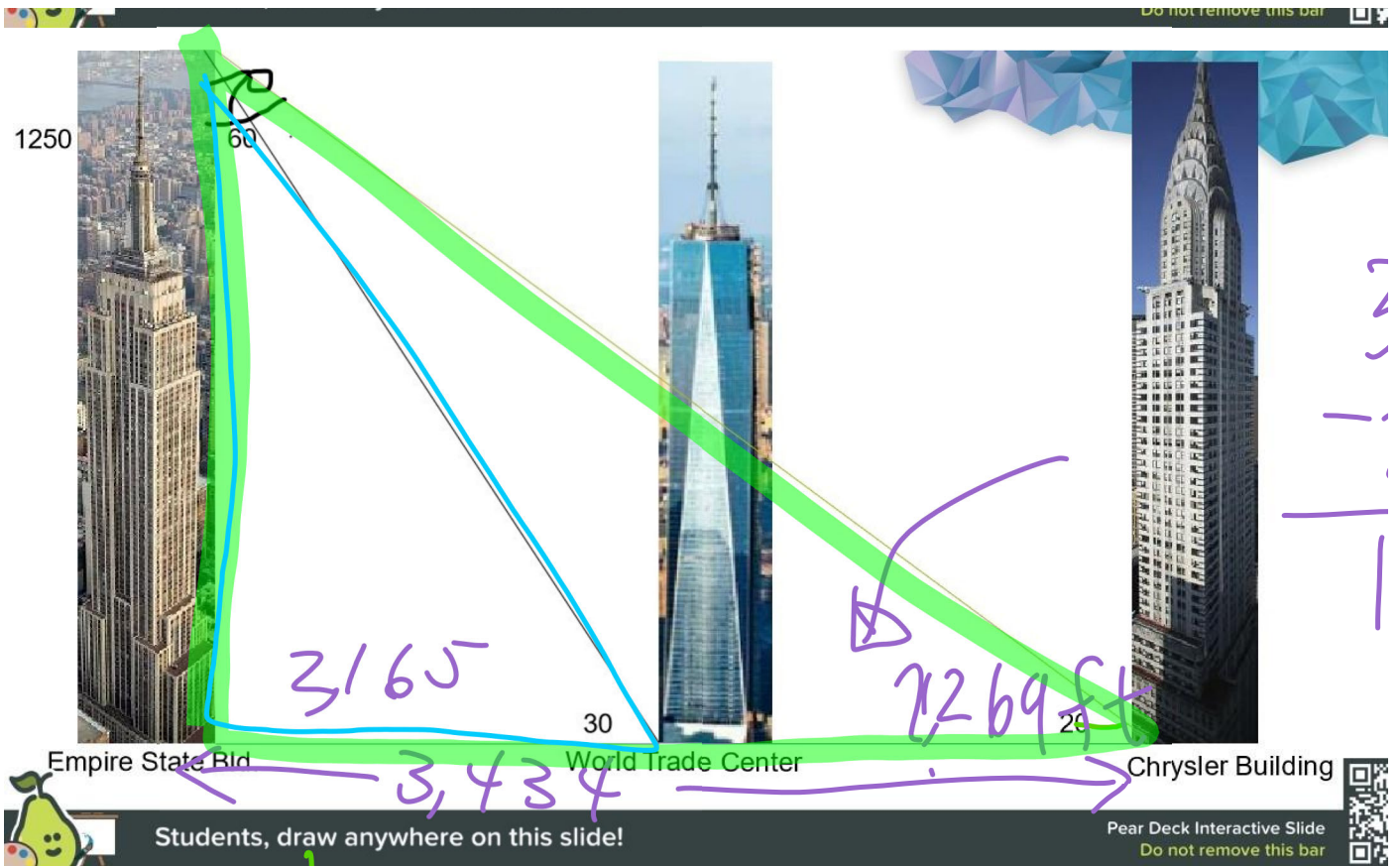
SIGHTSEEING Looking north, two skyscrapers are sighted from the viewing deck of the Empire State Building, which is at a height of 1250 feet. The base of one skyscraper is sighted at a 20° angle of depression and the base of a second skyscraper is sighted at a 30° angle of depression. How far apart are the two skyscrapers to the nearest foot?

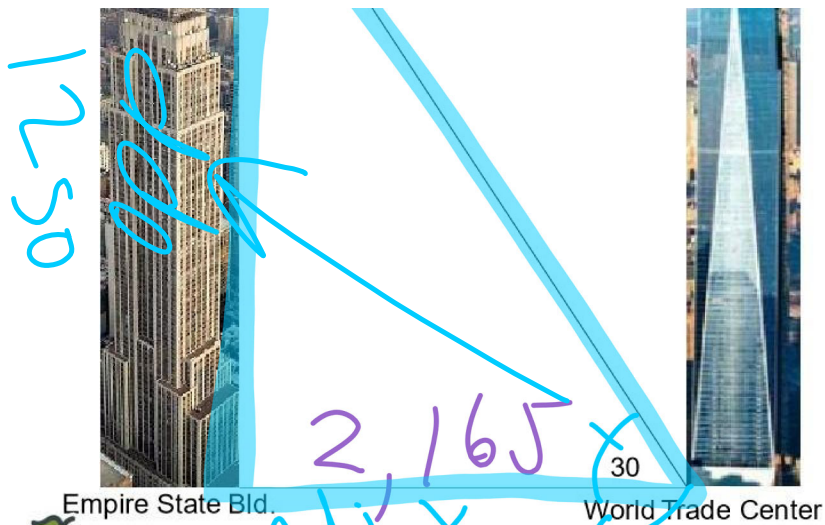


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$$\tan 30 = \frac{1250}{X}$$

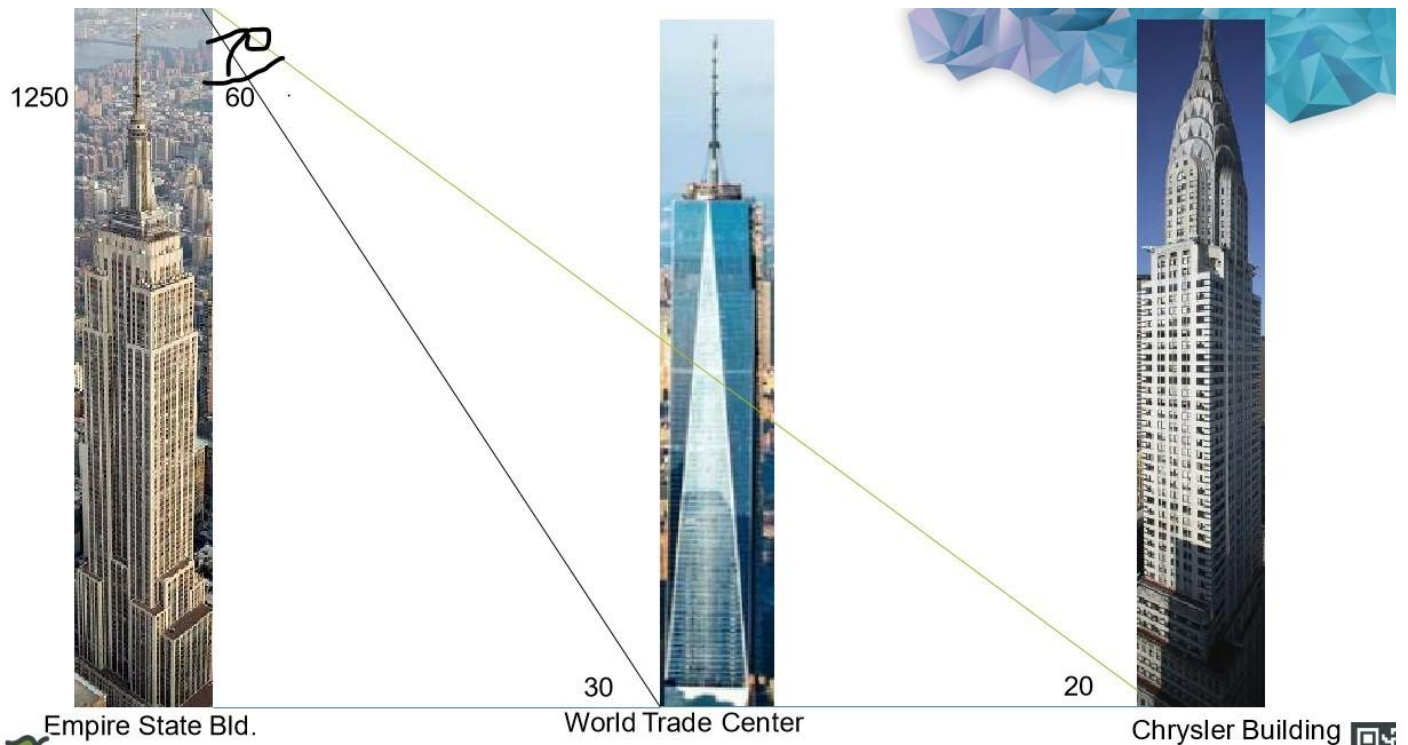
$$X(\tan 30) = 1250$$

$$X = \frac{1250}{\tan 30}$$



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