Understanding Tangents

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8.8 Understanding Tangents

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[Figure 1]

The members of the Volunteer Fire Department have been busy building a ramp at the entrance to the local arena to accommodate a young man who is confined to a wheelchair. Joey, who has recently moved to the small community, is about to try out the new ramp.

If the ramp covers a horizontal distance of 8.4 meters along the ground and rises to a height of 1.2 meters, how can Joey figure out what angle the ramp makes with the ground?

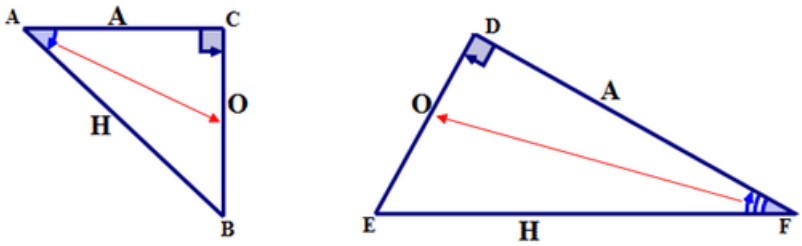
In this concept, you will learn to understand the trigonometric ratio Tangent.

Tangent Ratio

Trigonometry is a branch of mathematics used to determine the lengths of sides and the measure of angles with great accuracy. A ratio of the lengths of the sides of a right triangle is called a **trigonometric ratio**. The ratio of the length of the side opposite the reference angle to the length of the side alongside the reference angle is the **Tangent ratio**. An acute angle of a right triangle is formed by the hypotenuse and one of the legs of the triangle. This leg is called the **adjacent side** of the reference angle. The Tangent ratio is the ratio of the opposite side to the adjacent side.

In each given diagram, label each side of the right triangle as the:

Hypotenuse (H); Side *Opposite* reference angle (O); Side *Adjacent* to reference angle (A)



[Figure 2]

The Tangent ratio for the first triangle can be written in words as:

tangent of $\angle A = \dfrac{\text{side opposite } \angle A}{\text{side adjacent } \angle A}$ Or in a shortened form as $\tan A = \dfrac{\text{opposite}}{\text{adjacent}}$

The tangent ratio for the first triangle can be written in symbols as:

$$\tan A = \frac{BC}{AC}$$

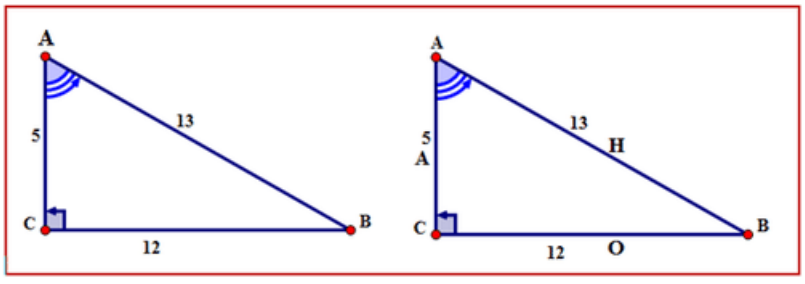
The tangent ratio for the second triangle can be written in words as:

tangent of $\angle F = \dfrac{\text{side opposite } \angle F}{\text{side adjacent } \angle F}$ Or in a shortened form as $\tan F = \dfrac{\text{opposite}}{\text{adjacent}}$

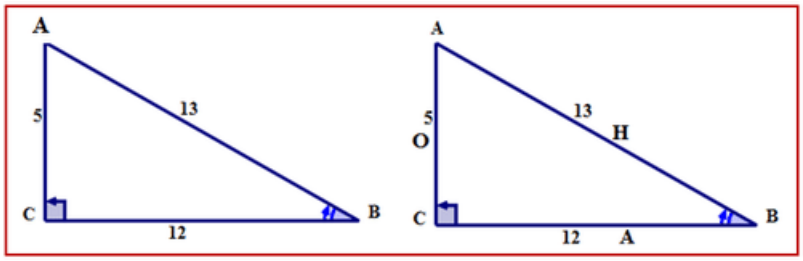
The Tangent ratio for the second triangle can be written in symbols as:

$$\tan F = \frac{DE}{EF}$$

Let's determine the value for the tangent ratio of each of the acute angles using the following right triangle. Express the tangent ratio in words and symbols. Then, using the values on the corresponding sides, replace the symbols with the numbers and express the ratio first as a fraction and then as a decimal rounded to the nearest ten thousandth (four places after the decimal).



[Figure 3]



[Figure 4]

$\triangle ABC$ with $\angle A$ as the reference angle.

First, name the sides of the triangle.

The hypotenuse is across from the right angle. The opposite side is across from $\angle A$. The side alongside $\angle A$ is the adjacent. The sides are labeled with the letters **H, O, A** respectively.

Next, write the tangent ratio for $\angle A$ in all of the required forms.

Words:

$$\text{tangent of } \angle A = \frac{\text{opposite}}{\text{adjacent}}$$

Symbols:

$$\tan A = \frac{BC}{AC}$$

Fraction:

$$\tan A = \frac{12}{5}$$

Decimal:

$$\tan A = 2.4$$

$\triangle ABC$ with $\angle B$ as the reference angle.

Notice that the locations of the opposite and adjacent sides have changed from where they were when $\angle A$ was the reference angle.

First, name the sides of the triangle.

The hypotenuse is across from the right angle. The opposite side is across from $\angle B$. The side alongside $\angle B$ is the adjacent. The sides are labeled with the letters **H, O, A** respectively.

Next, write the tangent ratio for $\angle B$ in all of the required forms.

Words:

tangent of $\angle B = \dfrac{\text{opposite}}{\text{adjacent}}$

Symbols:

$$\tan B = \frac{AC}{BC}$$

Fraction:

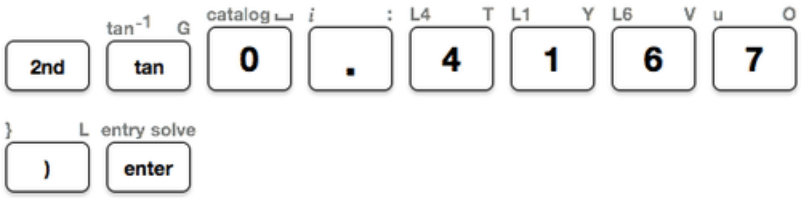
$$\tan B = \frac{5}{12}$$

Decimal:

$$\tan B = 0.4167$$

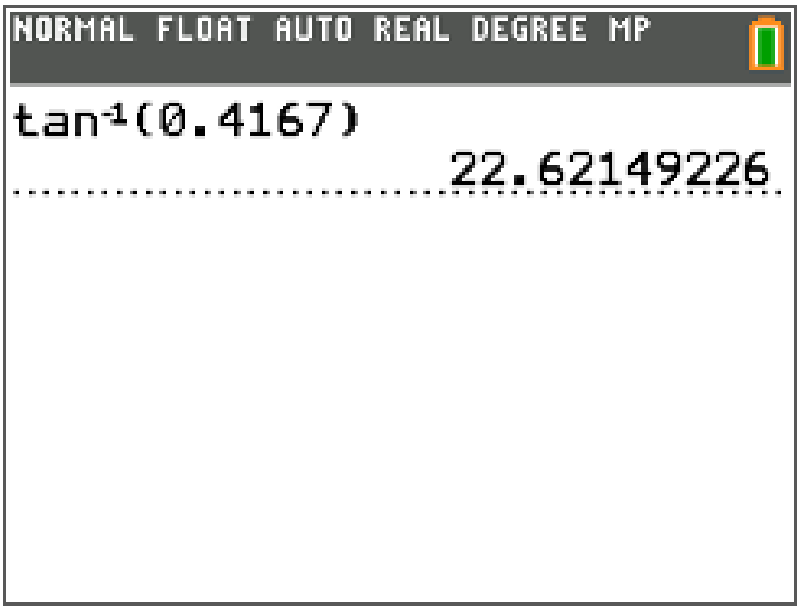
If $\tan B = 0.4167$, then the measure of $\angle B$ can be found using the inverse tangent function $\left(\tan^{-1}\right)$ on the TI- calculator.

First, follow the Key Press History below to calculate the measure of $\angle B$.



[Figure 5]

Next, look at the calculator screen to see the measure of $\angle B$.



[Figure 6]

Then, write the measure of $\angle B$ to the nearest tenth.

$$\angle B = 22.6^\circ$$

The answer is 22.6°.

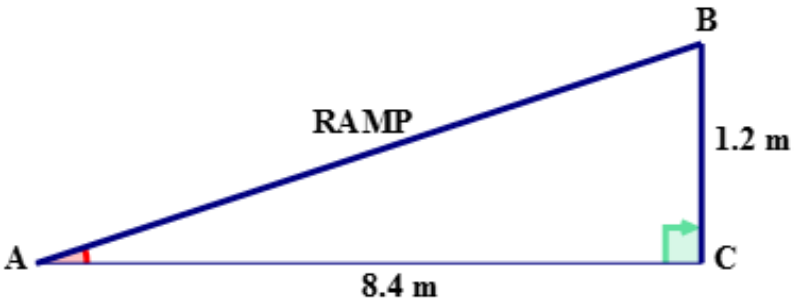
Examples

Example 1

Earlier, you were given a problem about Joey and the ramp. He is wondering what angle the ramp makes with the ground. How can Joey figure out the measure of this angle?

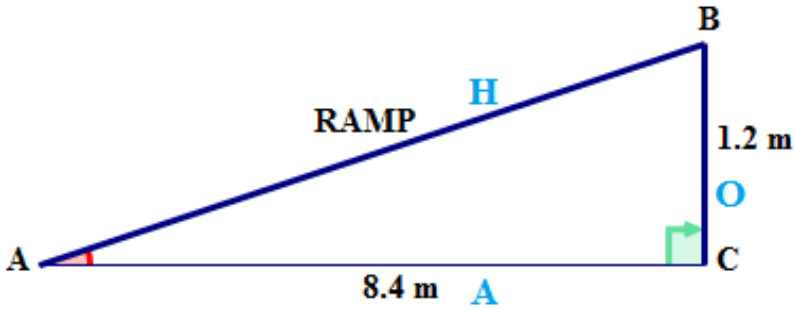
Joey can use the Tangent ratio and round his answer to the nearest hundredth.

First, draw and label a right triangle to model the problem.



[Figure 7]

Next, name the sides of the triangle using the reference angle A.



[Figure 8]

Next, write the tangent ratio in words.

$$\tan A = \frac{\text{opposite}}{\text{adjacent}}$$

Next, write the ratio using symbols.

$$\tan A = \frac{BC}{AC}$$

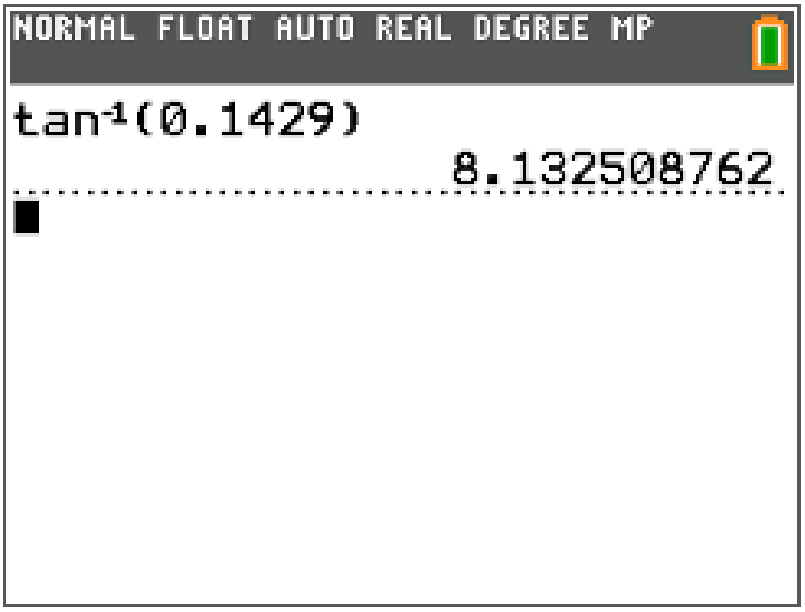
Next, express the ratio as a fraction using the values of the corresponding sides.

$$\tan A = \frac{1.2}{8.4}$$

Next, express the ratio as a decimal rounded to four places after the decimal.

$$\tan A = 0.1429$$

Next, use the inverse tangent function $\left(\tan^{-1}\right)$ on the TI calculator to find the measure of $\angle A$.



[Figure 9]

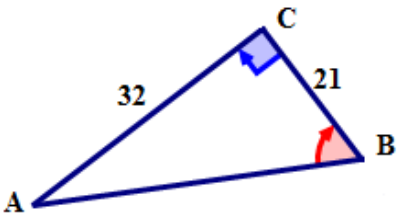
$$\angle A = 8.13^\circ$$

The answer is 8.13°.

The ramp makes an angle of 8.13° with the ground.

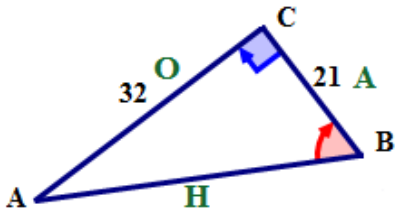
Example 2

For the following right triangle, use the tangent ratio to calculate the measure of $\angle B$, the reference angle, to the nearest tenth.



[Figure 10]

First, using the reference angle to name the sides of the triangle.



[Figure 11]

Next, write the tangent ratio in words.

$$\tan B = \frac{\text{opposite}}{\text{adjacent}}$$

Next, write the ratio using symbols.

$$\tan B = \frac{AC}{BC}$$

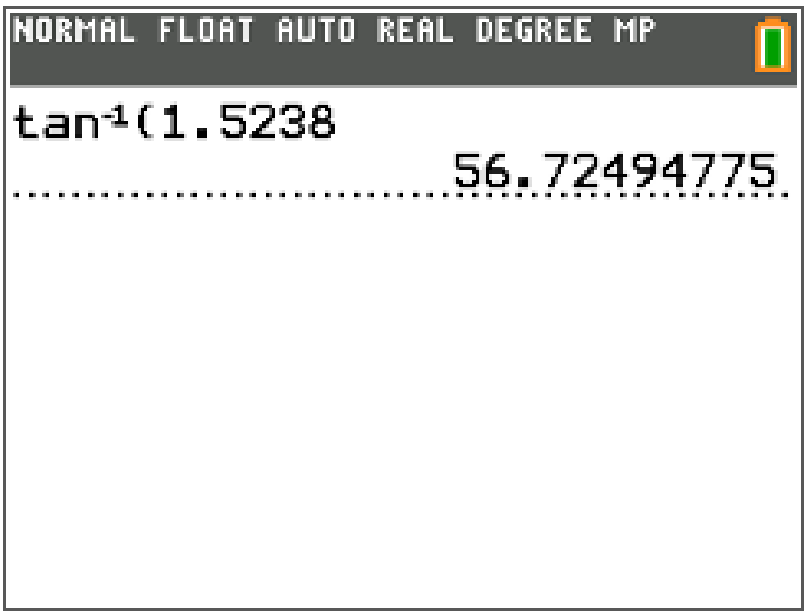
Next, express the ratio as a fraction using the values of the corresponding sides.

$$\tan B = \frac{32}{21}$$

Next, express the ratio as a decimal rounded to four places after the decimal.

$$\tan B = 1.5238$$

Next, use the inverse tangent function $\left(\tan^{-1}\right)$ on the TI calculator to find the measure of $\angle B$.



[Figure 12]

Then, write the value of $\angle B$ to the nearest tenth.

$$\angle B = 56.7°$$

The answer is 56.7°.

Example 3

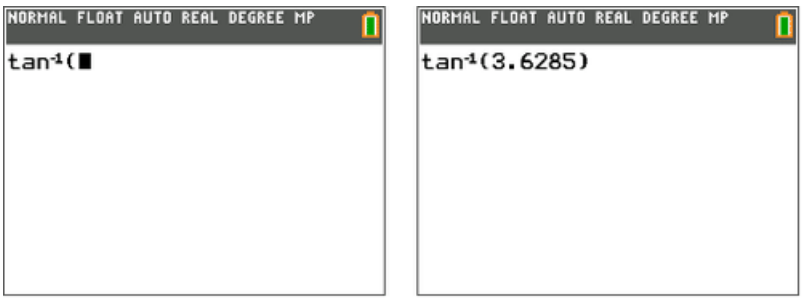
If $\tan C = 3.6285$, then what is the measure of $\angle C$ to the nearest tenth.

First, use the TI-calculator to find the measure of the angle by using the inverse tangent function $(\tan^{-1})$ located above the $\boxed{\tan}$ button on the calculator.

Next, to access this function press:

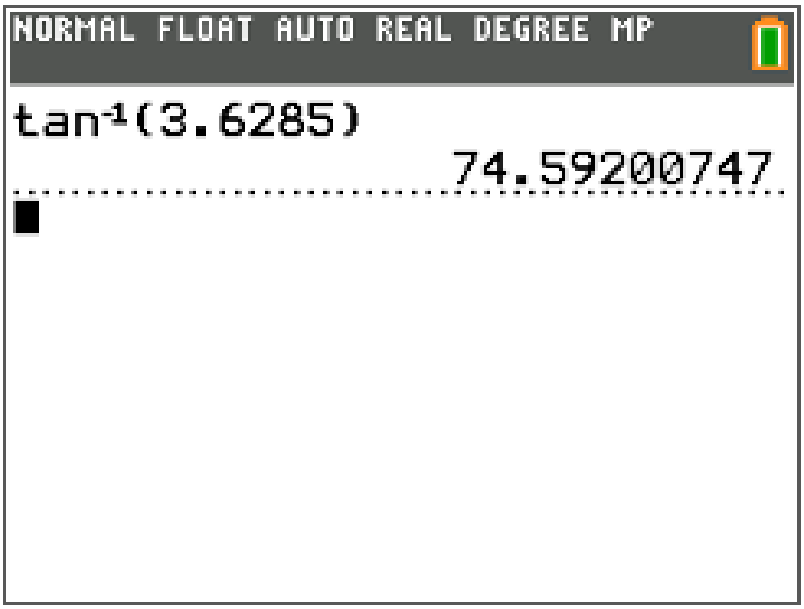
[Figure 13]

Next, enter the given decimal value inside the parenthesis where the cursor is flashing.



[Figure 14]

Next, press enter to see the measure of the angle on the screen.



[Figure 15]

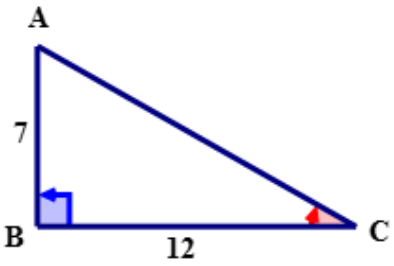
Then, write the value of $\angle C$ to the nearest tenth.

$$\angle C = 74.6^\circ$$

The answer is 74.6°.

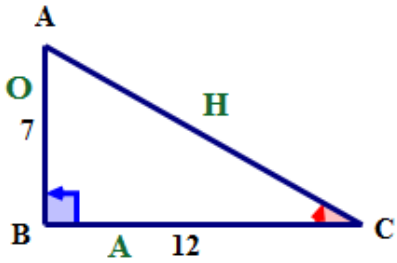
Example 4

For the following right triangle, use the tangent ratio to calculate the measure of $\angle C$ to the nearest hundredth.



[Figure 16]

First, using the reference angle to name the sides of the triangle.



[Figure 17]

Next, write the tangent ratio in words.

$$\tan C = \frac{\text{opposite}}{\text{adjacent}}$$

Next, write the ratio using symbols.

$$\tan C = \frac{AB}{BC}$$

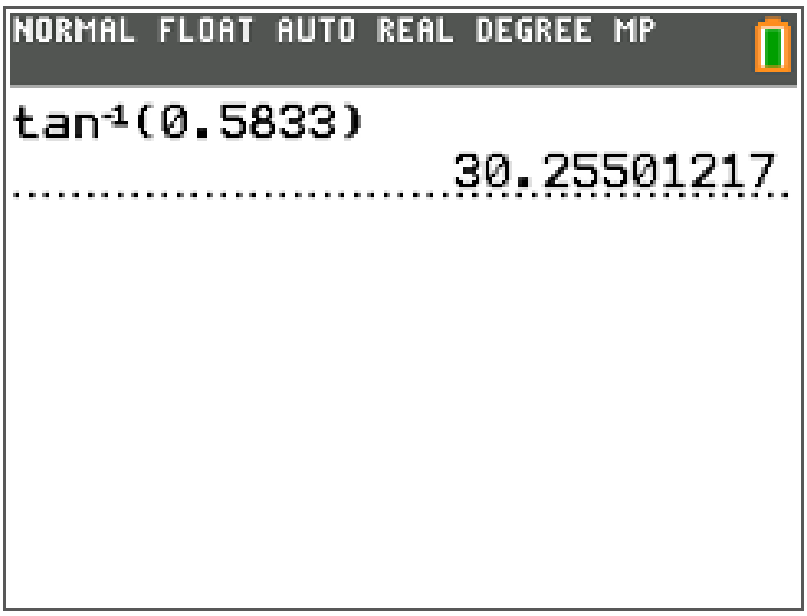
Next, express the ratio as a fraction using the values of the corresponding sides.

$$\tan C = \frac{7}{12}$$

Next, express the ratio as a decimal rounded to four places after the decimal.

$$\tan C = 0.5833$$

Next, use the inverse tangent function $\left(\tan^{-1}\right)$ on the TI calculator to find the measure of $\angle C$.



[Figure 18]

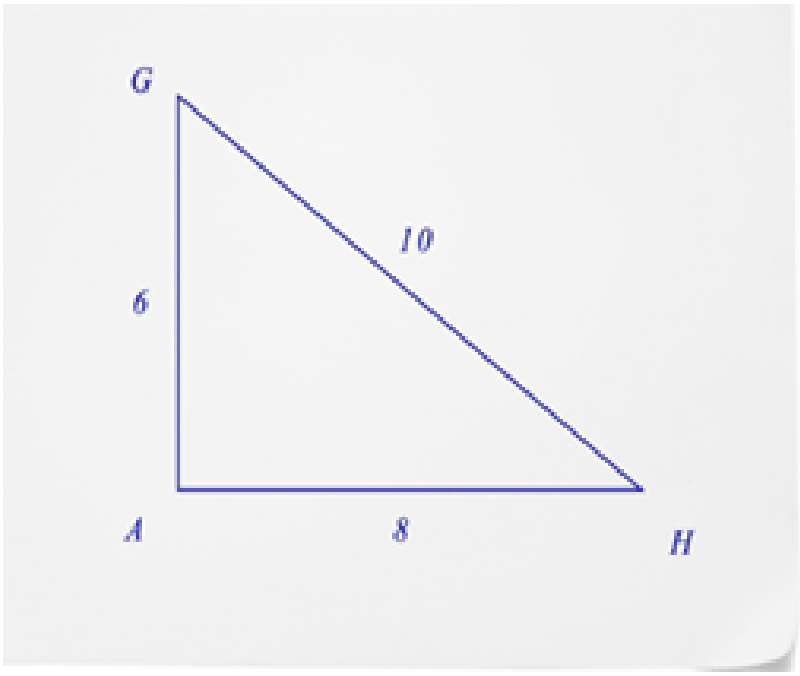
Then, write the value of $\angle C$ to the nearest hundredth.

$$\angle C = 30.26^\circ$$

The answer is 30.26°.

Review

Solve each problem. (Round your answer to the nearest hundredths place where needed)

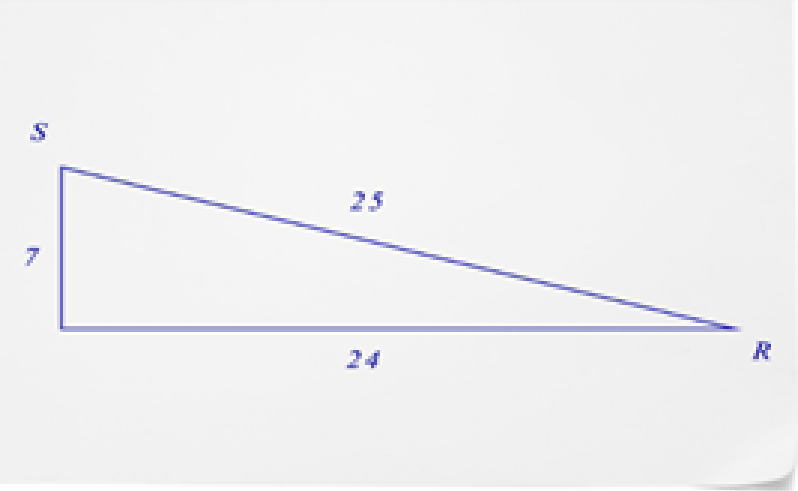


[Figure 19]

1. What is the tangent of $\angle G$?

2. What is the tangent of $\angle H$?

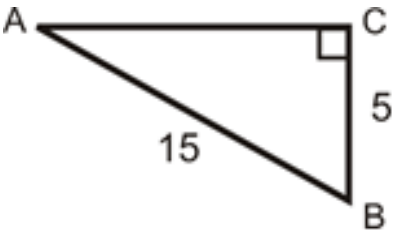
3. True or False. The sine and the tangent use the same ratios.



[Figure 20]

?$\angle R$ 4. What is the tangent of

5. What is the tangent of $\angle S$?



[Figure 21]

6. What is the tangent of $\angle A$?

7. What is the tangent of $\angle B$?

8. What is the length of the missing side rounded to the nearest hundredth?

Answer each of the following questions. You may round to the nearest hundredth.

9. If a tangent ratio is $\frac{4}{5}$ what is the measure of the tangent?

10. If a tangent ratio is $\frac{14}{20}$ what is the measure of the tangent?

11. If a tangent ratio is $\frac{6}{7}$ what is the measure of the tangent?

12. If a tangent ratio is $\frac{9}{2}$ what is the measure of the tangent?

13. If a tangent ratio is $\frac{4}{20}$ what is the measure of the tangent?

14. If a tangent ratio is $\frac{7}{21}$ what is the measure of the tangent?

15. If a tangent ratio is $\frac{9}{19}$ what is the measure of the tangent?

Review (Answers)

To see the review answers, return to the Table of Contents and select 'Other Versions' or 'Resources'.

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1.0 REFERENCES

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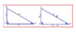	**Credit:** laura burns **Source:** https://www.flickr.com/photos/sass_face/3482842283/in/photolist-nAmpkv-72oLMV-72oMAa-2ygKdf-9Y2ari-qDZSqG-6iLtET-ENF1u-jQLJu2-2Na2BE-HEjvA-ut8iy6-3oy7SS-HEqqc-9daCvf-HEpgk-HEkGW-7CfBxK-5BTduc-8UaU6T-7u93iD-oazMDY-9Ahpnm-7DwUsV-7FggoT-7DAJy3-7DwUge-7DAGQL-7Fk8T9-7FgfGt-ey78dZ-auhzYb-oS8c72-oS58e9-4vu2YQ-acf7ft-acf7c6-9W1jdZ-dHF1a2-h6egXF-h9RH4J-9wVZ6i-6YHtRC-wzZuq-cs2Dwj-7KMLew-cs2DAC-aiG2if-6F1J9v-ss47E
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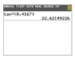
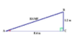
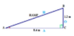
	**Credit:** laura burns **Source:** https://www.flickr.com/photos/sass_face/3482842283/in/photolist-nAmpkv-72oLMV-72oMAa-2ygKdf-9Y2ari-qDZSqG-6iLtET-ENF1u-jQLJu2-2Na2BE-HEjvA-ut8iy6-3oy7SS-HEqqc-9daCvf-HEpgk-HEkGW-7CfBxK-5BTduc-8UaU6T-7u93iD-oazMDY-9Ahpnm-7DwUsV-7FggoT-7DAJy3-7DwUge-7DAGQL-7Fk8T9-7FgfGt-ey78dZ-auhzYb-oS8c72-oS58e9-4vu2YQ-acf7ft-acf7c6-9W1jdZ-dHF1a2-h6egXF-h9RH4J-9wVZ6i-6YHtRC-wzZuq-cs2Dwj-7KMLew-cs2DAC-aiG2if-6F1J9v-ss47E
	**Credit:** laura burns **Source:** https://www.flickr.com/photos/sass_face/3482842283/in/photolist-nAmpkv-72oLMV-72oMAa-2ygKdf-9Y2ari-qDZSqG-6iLtET-ENF1u-jQLJu2-2Na2BE-HEjvA-ut8iy6-3oy7SS-HEqqc-9daCvf-HEpgk-HEkGW-7CfBxK-5BTduc-8UaU6T-7u93iD-oazMDY-9Ahpnm-7DwUsV-7FggoT-7DAJy3-7DwUge-7DAGQL-7Fk8T9-7FgfGt-ey78dZ-auhzYb-oS8c72-oS58e9-4vu2YQ-acf7ft-acf7c6-9W1jdZ-dHF1a2-h6egXF-h9RH4J-9wVZ6i-6YHtRC-wzZuq-cs2Dwj-7KMLew-cs2DAC-aiG2if-6F1J9v-ss47E
	**Credit:** laura burns **Source:** https://www.flickr.com/photos/sass_face/3482842283/in/photolist-nAmpkv-72oLMV-72oMAa-2ygKdf-9Y2ari-qDZSqG-6iLtET-ENF1u-jQLJu2-2Na2BE-HEjvA-ut8iy6-3oy7SS-HEqqc-9daCvf-HEpgk-HEkGW-7CfBxK-5BTduc-8UaU6T-7u93iD-oazMDY-9Ahpnm-7DwUsV-7FggoT-7DAJy3-7DwUge-7DAGQL-7Fk8T9-7FgfGt-ey78dZ-auhzYb-oS8c72-oS58e9-4vu2YQ-acf7ft-acf7c6-9W1jdZ-dHF1a2-h6egXF-h9RH4J-9wVZ6i-6YHtRC-wzZuq-cs2Dwj-7KMLew-cs2DAC-aiG2if-6F1J9v-ss47E
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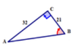
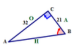
	**Credit:** laura burns **Source:** https://www.flickr.com/photos/sass_face/3482842283/in/photolist-nAmpkv-72oLMV-72oMAa-2ygKdf-9Y2ari-qDZSqG-6iLtET-ENF1u-jQLJu2-2Na2BE-HEjvA-ut8iy6-3oy7SS-HEqqc-9daCvf-HEpgk-HEkGW-7CfBxK-5BTduc-8UaU6T-7u93iD-oazMDY-9Ahpnm-7DwUsV-7FggoT-7DAJy3-7DwUge-7DAGQL-7Fk8T9-7FgfGt-ey78dZ-auhzYb-oS8c72-oS58e9-4vu2YQ-acf7ft-acf7c6-9W1jdZ-dHF1a2-h6egXF-h9RH4J-9wVZ6i-6YHtRC-wzZuq-cs2Dwj-7KMLew-cs2DAC-aiG2if-6F1J9v-ss47E
	**Credit:** laura burns **Source:** https://www.flickr.com/photos/sass_face/3482842283/in/photolist-nAmpkv-72oLMV-72oMAa-2ygKdf-9Y2ari-qDZSqG-6iLtET-ENF1u-jQLJu2-2Na2BE-HEjvA-ut8iy6-3oy7SS-HEqqc-9daCvf-HEpgk-HEkGW-7CfBxK-5BTduc-8UaU6T-7u93iD-oazMDY-9Ahpnm-7DwUsV-7FggoT-7DAJy3-7DwUge-7DAGQL-7Fk8T9-7FgfGt-ey78dZ-auhzYb-oS8c72-oS58e9-4vu2YQ-acf7ft-acf7c6-9W1jdZ-dHF1a2-h6egXF-h9RH4J-9wVZ6i-6YHtRC-wzZuq-cs2Dwj-7KMLew-cs2DAC-aiG2if-6F1J9v-ss47E
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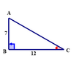
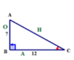
	**Credit:** laura burns **Source:** https://www.flickr.com/photos/sass_face/3482842283/in/photolist-nAmpkv-72oLMV-72oMAa-2ygKdf-9Y2ari-qDZSqG-6iLtET-ENF1u-jQLJu2-2Na2BE-HEjvA-ut8iy6-3oy7SS-HEqqc-9daCvf-HEpgk-HEkGW-7CfBxK-5BTduc-8UaU6T-7u93iD-oazMDY-9Ahpnm-7DwUsV-7FggoT-7DAJy3-7DwUge-7DAGQL-7Fk8T9-7FgfGt-ey78dZ-auhzYb-oS8c72-oS58e9-4vu2YQ-acf7ft-acf7c6-9W1jdZ-dHF1a2-h6egXF-h9RH4J-9wVZ6i-6YHtRC-wzZuq-cs2Dwj-7KMLew-cs2DAC-aiG2if-6F1J9v-ss47E
	**Credit:** laura burns **Source:** https://www.flickr.com/photos/sass_face/3482842283/in/photolist-nAmpkv-72oLMV-72oMAa-2ygKdf-9Y2ari-qDZSqG-6iLtET-ENF1u-jQLJu2-2Na2BE-HEjvA-ut8iy6-3oy7SS-HEqqc-9daCvf-HEpgk-HEkGW-7CfBxK-5BTduc-8UaU6T-7u93iD-oazMDY-9Ahpnm-7DwUsV-7FggoT-7DAJy3-7DwUge-7DAGQL-7Fk8T9-7FgfGt-ey78dZ-auhzYb-oS8c72-oS58e9-4vu2YQ-acf7ft-acf7c6-9W1jdZ-dHF1a2-h6egXF-h9RH4J-9wVZ6i-6YHtRC-wzZuq-cs2Dwj-7KMLew-cs2DAC-aiG2if-6F1J9v-ss47E

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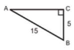	**Credit:** laura burns **Source:** https://www.flickr.com/photos/sass_face/3482842283/in/photolist-nAmpkv-72oLMV-72oMAa-2ygKdf-9Y2ari-qDZSqG-6iLtET-ENF1u-jQLJu2-2Na2BE-HEjvA-ut8iy6-3oy7SS-HEqqc-9daCvf-HEpgk-HEkGW-7CfBxK-5BTduc-8UaU6T-7u93iD-oazMDY-9Ahpnm-7DwUsV-7FggoT-7DAJy3-7DwUge-7DAGQL-7Fk8T9-7FgfGt-ey78dZ-auhzYb-oS8c72-oS58e9-4vu2YQ-acf7ft-acf7c6-9W1jdZ-dHF1a2-h6egXF-h9RH4J-9wVZ6i-6YHtRC-wzZuq-cs2Dwj-7KMLew-cs2DAC-aiG2if-6F1J9v-ss47E