

Trigonometric Ratios

Name: _____ Date: _____ Score: _____ / 28

Quick Review

You already know the three main ratios – sin, cos, tan. This section adds the three **reciprocal ratios** and the **quotient identity**, so you have all six.

The reciprocals.

$$\csc \theta = \frac{1}{\sin \theta} = \frac{\text{hyp}}{\text{opp}} \text{ (cosecant pairs with sine).}$$

$$\sec \theta = \frac{1}{\cos \theta} = \frac{\text{hyp}}{\text{adj}} \text{ (secant pairs with cosine).}$$

$$\cot \theta = \frac{1}{\tan \theta} = \frac{\text{adj}}{\text{opp}} \text{ (cotangent pairs with tangent).}$$

The quotient identity. $\tan \theta = \frac{\sin \theta}{\cos \theta}$, and consequently $\cot \theta = \frac{\cos \theta}{\sin \theta}$. These follow from the right-triangle definitions: $\frac{\sin \theta}{\cos \theta} = \frac{\text{opp/hyp}}{\text{adj/hyp}} = \frac{\text{opp}}{\text{adj}} = \tan \theta$.

Mnemonic. “co” with non-“co”: sin pairs with csc, cos pairs with sec, tan pairs with cot. The non-obvious one is that secant pairs with *cosine*, not sine – worth committing to memory.

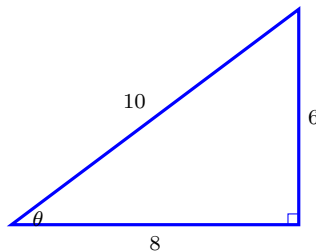
Sign behavior. Taking a reciprocal preserves sign. If $\sin \theta < 0$, then $\csc \theta < 0$ too; if $\cos \theta = -\frac{2}{3}$, then $\sec \theta = -\frac{3}{2}$.

Common slips. Confusing $\sin^{-1} \theta$ (inverse sine, an angle) with $\csc \theta$ (reciprocal of sine, a ratio). They are not the same thing. Pairing sec with sin instead of cos. Forgetting that all six ratios are positive for an acute angle in a right triangle.

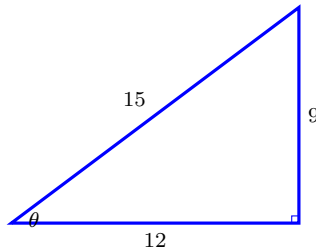
PRACTICE

Use right-triangle ratios and the reciprocal/quotient identities. All angles are acute unless stated.

1. If $\sin \theta = \frac{3}{5}$, find $\csc \theta$. _____
2. If $\cos \theta = \frac{8}{17}$, find $\sec \theta$. _____
3. If $\tan \theta = \frac{7}{24}$, find $\cot \theta$. _____
4. If $\sin \theta = \frac{3}{5}$ and $\cos \theta = \frac{4}{5}$, find $\tan \theta$. _____
5. In the right triangle below, θ is opposite the side 6. Find $\sec \theta$. _____



6. In the triangle below, θ is opposite the leg 9. Find $\tan \theta$. _____



7. Find $\sec 60^\circ$. _____

8. Find $\csc 30^\circ$. _____

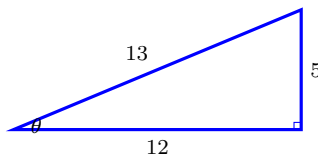
9. Find $\cot 45^\circ$. _____

10. If $\sin \theta = \frac{-\sqrt{2}}{2}$, find $\csc \theta$. _____

11. If $\cos \theta = -\frac{2}{3}$, find $\sec \theta$. _____

12. If $\sin \theta = \frac{3}{5}$ and $\cos \theta = \frac{4}{5}$, find $\cot \theta$. _____

13. In the triangle below, θ is opposite the leg of 5. Find $\csc \theta$. _____



14. Find $\sec 45^\circ$. _____

15. Find $\cot 60^\circ$. _____

16. If $\tan \theta = \frac{5}{12}$ for an acute θ , find $\sin \theta$. _____

17. If $\tan \theta = \frac{5}{12}$ for an acute θ , find $\cos \theta$. _____

18. If $\tan \theta = \frac{5}{12}$ for an acute θ , find $\cot \theta$. _____

19. Where is $\sec \theta$ undefined? _____

20. Find $\csc 90^\circ$. _____

◆ Word Problems

21. A ramp makes an angle of θ with level ground where $\sin \theta = \frac{3}{5}$. Find $\sec \theta$. _____

22. A guy-wire runs from the top of a 9-foot pole to a point 12 feet from the pole's base on level ground. Let θ be the angle the wire makes with the ground. Find $\csc \theta$, $\sec \theta$, and $\cot \theta$. _____

23. A right triangle has legs 5 and 12. If θ is opposite the leg of length 12, find all six trig ratios at θ . _____

24. An acute angle θ satisfies $\cos \theta = \frac{12}{13}$. Find all five other trig values at θ . _____



Additional Practice

25. Find $\sin \theta$ if opposite = 5, hypotenuse = 13. _____

26. Find $\cos \theta$ if adjacent = 12, hypotenuse = 13. _____

27. Find $\tan \theta$ if opposite = 7, adjacent = 4. _____

28. Find $\sin 30^\circ$. _____



Answer Keys

<p>1. $\frac{5}{3}$</p> <p>2. $\frac{17}{8}$</p> <p>3. $\frac{24}{7}$</p> <p>4. $\frac{3}{4}$</p> <p>5. $\frac{5}{4}$</p> <p>6. $\frac{3}{4}$</p> <p>7. 2</p> <p>8. 2</p> <p>9. 1</p> <p>10. $-\sqrt{2}$</p> <p>11. $-\frac{3}{2}$</p> <p>12. $\frac{4}{3}$</p> <p>Additional Practice Answers</p> <p>25. $\frac{5}{13}$</p> <p>26. $\frac{12}{13}$</p>	<p>13. $\frac{13}{5}$</p> <p>14. $\sqrt{2}$</p> <p>15. $\frac{\sqrt{3}}{3}$</p> <p>16. $\frac{5}{13}$</p> <p>17. $\frac{12}{13}$</p> <p>18. $\frac{12}{5}$</p> <p>19. $\cos \theta = 0$</p> <p>20. 1</p> <p>21. $\frac{5}{4}$</p> <p>22. $\csc \theta = \frac{5}{3}, \sec \theta = \frac{5}{4}, \cot \theta = \frac{4}{3}$</p> <p>23. $\sin = \frac{12}{13}, \cos = \frac{5}{13}, \tan = \frac{12}{5}, \csc = \frac{13}{12}, \sec = \frac{13}{5}, \cot = \frac{5}{12}$</p> <p>24. $\sin = \frac{5}{13}, \tan = \frac{5}{12}, \sec = \frac{13}{12}, \csc = \frac{13}{5}, \cot = \frac{12}{5}$</p> <p>27. $\frac{7}{4}$</p> <p>28. $\frac{1}{2}$</p>
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Additional Practice: Answers for all numbered items, including the added practice, are shown in the grid above.

Step-by-Step Explanations

- Cosecant is the reciprocal of sine, so flip the fraction: $\csc \theta = \frac{1}{\sin \theta} = \frac{1}{3/5} = \frac{5}{3}$. (Remember the “co” in cosecant pairs it with sine, not cosine.)
- Secant is the reciprocal of cosine, so flip: $\sec \theta = \frac{1}{8/17} = \frac{17}{8}$. (The tricky pairing to memorize: secant goes with *cosine*, not sine.)
- Cotangent is the reciprocal of tangent, so flip the fraction: $\cot \theta = \frac{1}{7/24} = \frac{24}{7}$.
- Start with the key idea: $\tan \theta = \frac{\sin \theta}{\cos \theta} = \frac{3/5}{4/5} = \frac{3}{4}$. (Same denominator – the fifths cancel.) That gives a quick check on the answer.
- A careful way to see it: Adjacent = 8, hyp = 10. $\sec \theta = \frac{\text{hyp}}{\text{adj}} = \frac{10}{8} = \frac{5}{4}$. This is the part to check before moving on, because it keeps the answer tied to the original question.
- Keep the rule visible: Opposite = 9, adjacent = 12. $\tan \theta = \frac{9}{12} = \frac{3}{4}$. This is the part to check before moving on, because it keeps the answer tied to the original question.
- One steady path is: $\cos 60^\circ = \frac{1}{2}$, so $\sec 60^\circ = \frac{1}{1/2} = 2$. This is the part to check before moving on, because it keeps the answer tied to the original question.
- Start with the key idea: $\sin 30^\circ = \frac{1}{2}$, so $\csc 30^\circ = 2$. This is the part to check before moving on, because it keeps the answer tied to the original question.
- A careful way to see it: $\tan 45^\circ = 1$, so $\cot 45^\circ = 1$. This is the part to check before moving on, because it keeps the answer tied to the original question.
- Flip the fraction: $\csc \theta = \frac{-2}{\sqrt{2}} = -\sqrt{2}$. (Multiply top and bottom by $\sqrt{2}$ to rationalize.)
- Secant is the reciprocal of cosine, and reciprocating never changes the sign: $\sec \theta = \frac{1}{-2/3} = -\frac{3}{2}$. A negative cosine forces a negative secant.

- Start with the key idea: $\cot \theta = \frac{\cos \theta}{\sin \theta} = \frac{4/5}{3/5} = \frac{4}{3}$. This is the part to check before moving on, because it keeps the answer tied to the original question.
- A careful way to see it: $\sin \theta = \frac{5}{13}$, so $\csc \theta = \frac{13}{5}$. This is the part to check before moving on, because it keeps the answer tied to the original question.
- Keep the rule visible: $\cos 45^\circ = \frac{\sqrt{2}}{2}$, so $\sec 45^\circ = \frac{2}{\sqrt{2}} = \sqrt{2}$. This is the part to check before moving on, because it keeps the answer tied to the original question.
- One steady path is: $\tan 60^\circ = \sqrt{3}$, so $\cot 60^\circ = \frac{1}{\sqrt{3}} = \frac{\sqrt{3}}{3}$ (rationalize). This is the part to check before moving on, because it keeps the answer tied to the original question.
- Start with the key idea: Opp = 5, adj = 12, so hyp = $\sqrt{25 + 144} = 15$. $\sin \theta = \frac{5}{13}$. This is the part to check before moving on, because it keeps the answer tied to the original question.
- A careful way to see it: From the same 5-12-13 setup: $\cos \theta = \frac{12}{13}$. This is the part to check before moving on, because it keeps the answer tied to the original question.
- Keep the rule visible: Cotangent is the reciprocal of tangent. This is the part to check before moving on, because it keeps the answer tied to the original question.
- One steady path is: $\sec \theta = \frac{1}{\cos \theta}$ blows up exactly when $\cos \theta = 0 -$ at $\theta = 90^\circ + 180^\circ n$ for integer n . That gives a quick check on the answer.
- Start with the key idea: $\sin 90^\circ = 1$, so $\csc 90^\circ = \frac{1}{1} = 1$. This is the part to check before moving on, because it keeps the answer tied to the original question.
- From $\sin \theta = \frac{3}{5}$: opposite = 3, hyp = 5, so adjacent = $\sqrt{25 - 9} = 4$. Then $\cos \theta = \frac{4}{5}$ and $\sec \theta = \frac{5}{4}$.
- This is a 9-12-15 right triangle: the pole and the ground distance are the legs (9 opposite θ , 12 adjacent), and the hypotenuse is $\sqrt{9^2 + 12^2} = 15$. So



$\sin \theta = \frac{9}{15} = \frac{3}{5}$, $\cos \theta = \frac{12}{15} = \frac{4}{5}$, $\tan \theta = \frac{9}{12} = \frac{3}{4}$. Flip each to get the reciprocals.

23. With θ opposite the leg of 12: opposite = 12, adjacent = 5, hyp = $\sqrt{25 + 144} = 13$. The three primary ratios: $\sin \theta = \frac{12}{13}$, $\cos \theta = \frac{5}{13}$,

$\tan \theta = \frac{12}{5}$. Flip for the reciprocals: $\csc = \frac{13}{12}$, $\sec = \frac{13}{5}$, $\cot = \frac{5}{12}$.

24. Cosine gives adjacent = 12, hyp = 13. Opposite = $\sqrt{169 - 144} = 5$. So $\sin \theta = \frac{5}{13}$, $\tan \theta = \frac{5}{12}$. Reciprocals: $\sec = \frac{13}{12}$, $\csc = \frac{13}{5}$, $\cot = \frac{12}{5}$. (Notice this is the 5-12-13 Pythagorean triple again – it shows up a lot.)



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