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CHAPTER NOTES

Introduction to Trigonometry Class 10 Notes | CBSE Maths Chapter 8

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Hi, I am **Ira**. I teach this syllabus all day, so **Introduction to Trigonometry** is very much my home ground.

Ask me anything from this chapter. A concept, a numerical, or that one doubt you did not want to raise in class. Pick one to start:

Explain Introduction to Trigonometry simply

What can the board exam ask?

Most important formulas

Quiz me on this chapter

Ask Ira anything...



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Introduction to Trigonometry Class 10 Notes | CBSE Maths Chapter 8

Introduction to Trigonometry is Chapter 8 of CBSE Class 10 Maths. Trigonometry is the study of the relationships between the sides and the angles of a triangle, and this chapter starts that study with the acute angles of a right triangle. It covers the six trigonometric ratios (sin, cos, tan, cosec, sec, cot), finding all six ratios when one is known, the values of the ratios for 0° , 30° , 45° , 60° and 90° , and the three trigonometric identities.

For board exams the chapter has two sides. One side is calculation: find a ratio from given sides, evaluate an expression with standard values, or find a missing side or angle. The other side is proof: show that an identity holds, step by step, starting from one side. Chapter 9, Some Applications of Trigonometry, uses the ratios and standard values from this chapter to find heights and distances, so a firm grip here pays off twice.

Quick Answer - Introduction to Trigonometry

In triangle ABC right-angled at B, for an angle A, $\sin A = \frac{\text{opposite}}{\text{hypotenuse}} = \frac{BC}{AC}$, $\cos A = \frac{\text{adjacent}}{\text{hypotenuse}} = \frac{AB}{AC}$, $\tan A = \frac{\text{opposite}}{\text{adjacent}} = \frac{BC}{AB}$, $\text{cosec } A = \frac{1}{\sin A}$, $\sec A = \frac{1}{\cos A}$, and $\cot A = \frac{1}{\tan A}$. The values of the ratios for 0° , 30° , 45° , 60° and 90° (sin goes 0, $1/2$, $1/\sqrt{2}$, $\sqrt{3}/2$, 1). The three trigonometric identities are $\sin^2 A + \cos^2 A = 1$, $\sec^2 A = 1 + \tan^2 A$, and $\text{cosec}^2 A = 1 + \cot^2 A$.



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All Key Formulas at a Glance

Idea	Formula	Use it when
Sine	$\sin A = \text{opposite} / \text{hypotenuse}$	The side facing the angle and the hypotenuse are involved
Cosine	$\cos A = \text{adjacent} / \text{hypotenuse}$	The side next to the angle and the hypotenuse are involved
Tangent	$\tan A = \text{opposite} / \text{adjacent}$	Both legs are involved, the hypotenuse is not
Reciprocal ratios	$\operatorname{cosec} A = 1/\sin A, \sec A = 1/\cos A, \cot A = 1/\tan A$	Converting to sin and cos
Quotient relations	$\tan A = \sin A / \cos A$ $\cot A = \cos A / \sin A$	
Standard values of sin	0, 1/2, 1/√2, √3/2, 1 45°, 60°, 90°	
Standard values of tan	0, 1/√3, 1, √3, not defined	
Identity 1	$\sin^2 A + \cos^2 A = 1,$	
Identity 2	$1 + \tan^2 A = \sec^2 A,$ 90°	
Identity 3	$\cot^2 A + 1 = \operatorname{cosec}^2 A,$ 90°	

Key Concepts

1. What Trigonometry Studies

The word **trigonometry** comes from three Greek words: *trigonon* (triangle) and *metron* (measure). Trigonometry is the study of the relationships between the sides and angles of a triangle.



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triangle.

The NCERT chapter opens with situations where a right triangle can be imagined: a student looking at the top of the Qutub Minar, a girl on a balcony looking at a flower pot across a river, and a hot air balloon moving across the sky. In each, a height or distance is wanted without measuring it directly.

In this chapter we work only with **acute angles** of a right triangle, and we also define the ratios for 0° and 90° . The ratios can be extended to other angles, which you will meet in higher classes.

Naming the sides with respect to an angle

Take triangle ABC, right-angled at B. Look at the acute angle A (that is, angle CAB).

- **BC** faces angle A. It is the **side opposite** to angle A.
- **AC** faces the right angle. It is the **hypotenuse**, the longest side.
- **AB** is one of the two arms of angle A and the other is BC.

Now switch to angle C. The side opposite angle C is AB. The hypotenuse is still AC. So the labels “opposite” and “hypotenuse” are always looking at. The hypotenuse is the only side common to both angles.

Side of triangle ABC (right angle at B)
BC
AB
AC

2. The Six Trigonometric Ratios

A **trigonometric ratio** of an acute angle is the ratio of the sides of a right triangle. In triangle ABC, right-angled at B, the trigonometric ratios are defined as follows:



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Ratio	Short form	Definition	In triangle ABC
sine of angle A	$\sin A$	side opposite to A / hypotenuse	BC/AC
cosine of angle A	$\cos A$	side adjacent to A / hypotenuse	AB/AC
tangent of angle A	$\tan A$	side opposite to A / side adjacent to A	BC/AB
cosecant of angle A	$\operatorname{cosec} A$	hypotenuse / side opposite to A = $1/\sin A$	AC/BC
secant of angle A	$\sec A$	hypotenuse / side adjacent to A = $1/\cos A$	AC/AB
cotangent of angle A	$\cot A$	side adjacent to A / side opposite to A = $1/\tan A$	

The last three are the **reciprocals** of the first three. For example, $\operatorname{cosec} A = 1/\sin A$.

Two quotient relations

Dividing top and bottom of BC/AB by AC : $\tan A = \frac{BC/AC}{AB/AC} = \frac{\sin A}{\cos A}$.

These two relations let you rewrite any expression in terms of $\sin$ and $\cos$. The safest first move in most proofs.

Ratios of angle C in the same triangle

For angle C in the same triangle, $\sin C = \frac{AB}{AC}$ and $\cos C = \frac{BC}{AC}$. Notice how the sides swap when you move from A to C.

What the symbol means

$\sin A$ is one symbol for "the sine of the angle A". It can also be written $\sin^2 A$. $\operatorname{cosec} A = (\sin A)^{-1}$, which doesn't work in all classes). The Greek letter θ is often used to represent an angle.



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3. Ratios Depend Only on the Angle

Take triangle ABC right-angled at B. Choose a point P on the hypotenuse AC and drop a perpendicular PM to AB. Choose a point Q on AC extended and drop a perpendicular QN to AB extended. Now there are three right triangles that all contain angle A: triangle PAM, triangle CAB and triangle QAN.

Triangles PAM and CAB share angle A and each has a right angle, so by the **AA similarity criterion** (Chapter 6) they are similar. Corresponding sides of similar triangles are proportional:

$$AM/AB = AP/AC = MP/BC$$

Rearranging, $MP/AP = BC/AC = \sin A$, $AM/AP = AB/AC = \cos A$, and $MP/AM = BC/AB = \tan A$. The same argument works for triangle QAN.

Conclusion: the values of the trigonometric ratios of an angle do not vary with the lengths of the sides of the triangle, if the angle remains the same.

This is why, given $\sin A = 1/3$, you may calculate $\cos A$ and $\tan A$.

Bounds on the ratios

The hypotenuse is the longest side, so the ratios of the other two sides to the hypotenuse are **$0 \leq \sin A \leq 1$** and **$0 \leq \cos A \leq 1$** for $0^\circ \leq A \leq 90^\circ$.

Their reciprocals $\sec A$ (for $0^\circ \leq A < 90^\circ$) and $\csc A$ are **greater than or equal to 1**.

$\tan A$ has no upper bound: $\tan 60^\circ = \sqrt{3}$ is less than $\tan 70^\circ$.

4. Finding All Six Ratios from One Ratio

If one trigonometric ratio of an acute angle is given, you can find the other five using the definitions, one positive multiplier and one sign.

1. Write the given ratio as a ratio of two numbers.
2. Give those two sides lengths in terms of a number.
3. Find the third side by the Pythagoras theorem. The length is positive.
4. Write the remaining ratios straight from their definitions.



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NCERT illustration. In right triangle ABC (right angle at B), $\sin A = 1/3$. Then $BC/AC = 1/3$, so let $BC = k$ and $AC = 3k$.

$AB^2 = AC^2 - BC^2 = (3k)^2 - k^2 = 8k^2 = (2\sqrt{2} k)^2$, so $AB = 2\sqrt{2} k$.

The negative value $-2\sqrt{2} k$ is rejected because AB is a length. Now $\cos A = AB/AC = 2\sqrt{2} k / 3k = 2\sqrt{2}/3$, $\tan A = BC/AB = 1/(2\sqrt{2})$, and the reciprocals follow: $\operatorname{cosec} A = 3$, $\sec A = 3/(2\sqrt{2})$, $\cot A = 2\sqrt{2}$.

Pythagorean triples that appear again and again

Many questions are built on whole-number right triangles. Spotting them saves time.

Legs	Hypotenuse	Where it appears in the chapter
3, 4	5	$\tan A = 4/3$ (NCERT Example 1); $3 \cot A = 4$ (Exercise 8.1)
5, 12	13	$\sec \theta = 13/12$
7, 24	25	$AB = 24$ cm, Example 5)
8, 15	17	$15 \cot A = 8$
20, 21	29	$AB = 29$, BC



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The identities of Concept 7 give a second $\sin A = 2/\sqrt{3}$, $\cos A = \sqrt{3}/2$ and $\sin A = \sqrt{1 - 3/4}$

5. Trigonometric Ratios of 45°, 30°

These values are derived from two simple diagrams. You can rebuild the table in the exam hall if memorise.

45°: the isosceles right triangle

In triangle ABC right-angled at B, let angle A = angle C. Angles A and C add up to 180°. Sides opposite equal angles are equal.

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By the Pythagoras theorem, $AC^2 = a^2 + a^2 = 2a^2$, so $AC = a\sqrt{2}$.

- $\sin 45^\circ = BC/AC = a/(a\sqrt{2}) = 1/\sqrt{2}$
- $\cos 45^\circ = AB/AC = 1/\sqrt{2}$
- $\tan 45^\circ = BC/AB = a/a = 1$
- $\operatorname{cosec} 45^\circ = \sqrt{2}$, $\sec 45^\circ = \sqrt{2}$, $\cot 45^\circ = 1$

30° and 60°: half of an equilateral triangle

Take an equilateral triangle ABC, so each angle is 60°. Draw the perpendicular AD from A to BC. Triangles ABD and ACD are congruent (RHS: hypotenuse AB = AC, common side AD, right angles at D). So BD = DC and angle BAD = angle CAD (CPCT). This makes triangle ABD a right triangle, right-angled at D, with angle BAD = 30° and angle ABD = 60°.

Let AB = 2a. Then BD = half of BC = a, and $AD^2 = AB^2 - BD^2 = 4a^2 - a^2 = 3a^2$, so $AD = a\sqrt{3}$.

For 30° (angle BAD): opposite side is BD =



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- $\sin 30^\circ = BD/AB = 1/2$, $\cos 30^\circ = AD/AB = \sqrt{3}/2$
- $\operatorname{cosec} 30^\circ = 2$, $\sec 30^\circ = 2/\sqrt{3}$, $\cot 30^\circ = \sqrt{3}$



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For 60° (angle ABD): opposite side is AD =

- $\sin 60^\circ = \sqrt{3}/2$, $\cos 60^\circ = 1/2$, $\tan 60^\circ = \sqrt{3}$
- $\operatorname{cosec} 60^\circ = 2/\sqrt{3}$, $\sec 60^\circ = 2$, $\cot 60^\circ = 1/\sqrt{3}$

Notice that the values for 30° and 60° are swapped. 30° and 60° are the two acute angles in a right triangle, and one is adjacent to the other.

6. Ratios of 0° and 90° and the Cotangent

In triangle ABC right-angled at B, let angle A becomes almost equal to AB, so $\sin A = BC/AB \approx 1$. So we define **$\sin 0^\circ = 0$ and $\cos 0^\circ = 1$** . The values of $\operatorname{cosec} 0^\circ = 1/0$ are **not defined**.

Now let A grow towards 90°. Angle C shrinks towards 0°. Angle C approaches 0°, so $\sin C$ approaches 0 and $\cos C$ approaches 1.

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Then $\cot 90^\circ = 0$ and $\operatorname{cosec} 90^\circ = 1$, while $\tan 90^\circ$ and $\sec 90^\circ$ need division by 0 and are **not defined**.

Table 8.1: values for the standard angles

Ratio	0°	30°	45°	60°	90°
sin A	0	1/2	1/√2	√3/2	1
cos A	1	√3/2	1/√2	1/2	0
tan A	0	1/√3	1	√3	Not defined
cosec A	Not defined	2	√2	2/√3	1
sec A	1	2/√3	√2	2	Not defined
cot A	Not defined	√3	1	1/√3	0

How the table behaves. As A increases from 0° to 90°, sin A increases from 0 to 1 and cos A decreases from 1 to 0. tan A also increases from 0 to ∞.

A memory aid for the first row

Write the numbers 0, 1, 2, 3, 4 under 0°, 30°, 45°, 60°, 90° respectively. Then take the square root of the numbers under 0°, 30°, 45°, 60° to get the first row.

$\sqrt{0/4} = 0, \sqrt{1/4} = 1/2, \sqrt{2/4} = 1/\sqrt{2}, \sqrt{3/4} = \sqrt{3}/2$

That is the sin row. Write it backwards to get the cos row. Take reciprocals to get the last three rows.

Finding sides and angles. If one side and one angle of a right triangle are known, the remaining sides and angles can be found. What you know with what you want, and remember the trigonometric ratios. For example, if the angle is 30° and the side opposite to it is 1, then the hypotenuse is 2.



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7. Trigonometric Identities

An equation is an **identity** when it is true for all values of the variables involved. An equation involving trigonometric ratios of an angle is a **trigonometric identity** if it is true for all values of the angle(s) involved. An ordinary equation, such as $\sin A = 1/2$, is true only for particular angles.

Proving the first identity

In triangle ABC right-angled at B, the Pythagoras theorem gives

$$AB^2 + BC^2 = AC^2 \quad (1)$$

Divide every term of (1) by AC^2 : $(AB/AC)^2 + (BC/AC)^2 = (AC/AC)^2$, that is $(\cos A)^2 + (\sin A)^2 = 1$:

$$\cos^2 A + \sin^2 A = 1 \quad (2)$$

This holds for all A with $0^\circ \leq A \leq 90^\circ$. At 0° it reads $1 + 0 = 1$ and at 90° it reads $0 + 1 = 1$.

The second identity

Divide (1) by AB^2 : $(AB/AB)^2 + (BC/AB)^2 = (AC/AB)^2$

$$1 + \tan^2 A = \sec^2 A \quad (3)$$

At $A = 0^\circ$ it reads $1 + 0 = 1$, which is true. A true for all A with $0^\circ \leq A < 90^\circ$.

The third identity

Divide (1) by BC^2 : $(AB/BC)^2 + (BC/BC)^2 = (AC/BC)^2$

$$\cot^2 A + 1 = \operatorname{cosec}^2 A \quad (4)$$

$\operatorname{cosec} A$ and $\cot A$ are not defined at $A = 0^\circ$

Useful rearranged forms



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Identity	Rearranged forms	Factorised form
$\sin^2 A + \cos^2 A = 1$	$\sin^2 A = 1 - \cos^2 A$; $\cos^2 A = 1 - \sin^2 A$	$(1 - \sin A)(1 + \sin A) = \cos^2 A$; $(1 - \cos A)(1 + \cos A) = \sin^2 A$
$1 + \tan^2 A = \sec^2 A$	$\sec^2 A - \tan^2 A = 1$	$(\sec A - \tan A)(\sec A + \tan A) = 1$
$\cot^2 A + 1 = \operatorname{cosec}^2 A$	$\operatorname{cosec}^2 A - \cot^2 A = 1$	$(\operatorname{cosec} A - \cot A)(\operatorname{cosec} A + \cot A) = 1$

The factorised forms are the hidden key to many proofs. For example, $(\sec A - \tan A)(\sec A + \tan A) = 1$ tells you at once that $\sec A + \tan A = 1/(\sec A - \tan A)$.

Expressing one ratio in terms of another

The identities let you write every ratio in terms of $\sin A$ and $\cos A$. For example, you can write $\tan A$ and $\sec A$ in terms of $\sin A$:

- $\cos^2 A = 1 - \sin^2 A$, so $\cos A = \sqrt{1 - \sin^2 A}$ (if $\cos A$ is positive).
- $\tan A = \sin A / \cos A = \sin A / \sqrt{1 - \sin^2 A}$
- $\sec A = 1 / \cos A = 1 / \sqrt{1 - \sin^2 A}$

A method for proving identities

Start from the more complicated side and work towards the simpler side (or both sides separately). Rewrite mixed ratios in terms of $\sin$ and $\cos$ (or $\tan$ and $\sec$), and then use the factorised form. If the question names an identity, use it. Replace functions in and replace 1 by, for example, $\sin^2 A + \cos^2 A$.



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Formula and Theorem Sheet

Result	Statement	Valid for
Reciprocals	$\operatorname{cosec} A = 1/\sin A$, $\sec A = 1/\cos A$, $\cot A = 1/\tan A$	Wherever the denominator is not zero
Quotients	$\tan A = \sin A / \cos A$, $\cot A = \cos A / \sin A$	Wherever the denominator is not zero
0°	$\sin 0^\circ = 0$, $\cos 0^\circ = 1$, $\tan 0^\circ = 0$; $\cot 0^\circ$ and $\operatorname{cosec} 0^\circ$ not defined	By definition
30°	$\sin 30^\circ = 1/2$, $\cos 30^\circ = \sqrt{3}/2$, $\tan 30^\circ = 1/\sqrt{3}$	Half equilateral triangle
45°	$\sin 45^\circ = \cos 45^\circ = 1/\sqrt{2}$, $\tan 45^\circ = 1$	Isosceles right triangle
60°	$\sin 60^\circ = \sqrt{3}/2$, $\cos 60^\circ = 1/2$, $\tan 60^\circ = \sqrt{3}$	
90°	$\sin 90^\circ = 1$, $\cos 90^\circ = 0$, $\tan 90^\circ$ not defined, and $\sec 90^\circ$ not defined	
Identity 1	$\sin^2 A + \cos^2 A = 1$	
Identity 2	$1 + \tan^2 A = \sec^2 A$	
Identity 3	$\cot^2 A + 1 = \operatorname{cosec}^2 A$	



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Important Definitions

- **Trigonometry:** the study of relationship name comes from the Greek *tri* (three),
- **Hypotenuse:** the side opposite the right angle.
- **Side opposite to an angle:** the side of the triangle opposite to the angle.
- **Side adjacent to an angle:** the side that forms the angle with the hypotenuse.

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- **sin A, cos A, tan A:** opposite/hypotenuse, adjacent/hypotenuse and opposite/adjacent for angle A; cosec, sec and cot are their reciprocals.
- **Not defined:** a ratio whose calculation would need division by zero, such as $\tan 90^\circ$, $\sec 90^\circ$, $\cot 0^\circ$ and $\operatorname{cosec} 0^\circ$.
- **Identity:** an equation that is true for all values of the variables involved.
- **Trigonometric identity:** an equation involving trigonometric ratios of an angle that is true for all values of the angle(s) involved.

Solved Examples (NCERT-Based)

Example 1: All ratios from tan A (NCERT Example 1)

Question: Given $\tan A = 4/3$, find the other trigonometric ratios of the angle A.

Solution: Draw triangle ABC right-angled at B such that $AB = 4k$ and $BC = 3k$, where k is a positive number.

By the Pythagoras theorem, $AC^2 = AB^2 + BC^2 = 16k^2 + 9k^2 = 25k^2$

$\sin A = BC/AC = 3k/5k = 3/5$ and $\cos A = AB/AC = 4k/5k = 4/5$

$\cot A = 1/\tan A = 3/4$, $\operatorname{cosec} A = 1/\sin A = 5/3$

Example 2: Two triangles, 24 and 7 (NCERT Example 2)

Question: In ΔABC , right-angled at B, $AB = 24$ and $BC = 7$. Find $\sin C$, $\cos C$

Solution: $AC^2 = AB^2 + BC^2 = 576 + 49 = 625$

(i) For angle A, the opposite side is BC and the hypotenuse is AC.
 $\sin A = BC/AC = 7/25$.

(ii) For angle C, the opposite side is AB and the hypotenuse is AC.
 $\cos C = BC/AC = 7/25$.



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Example 3: From cot A to sin A and sec A (NCERT Exercise 8.1, Q4)

Question: Given $15 \cot A = 8$, find $\sin A$ and $\sec A$.

Solution: $\cot A = 8/15 = \text{adjacent/opposite}$. In triangle ABC right-angled at B, let $AB = 8k$ and $BC = 15k$.

$$AC^2 = (8k)^2 + (15k)^2 = 64k^2 + 225k^2 = 289k^2, \text{ so } AC = 17k.$$

$$\sin A = BC/AC = 15/17 \text{ and } \sec A = AC/AB = 17/8.$$

Example 4: A sum of two sides (NCERT Exercise 8.1, Q10)

Question: In ΔPQR , right-angled at Q, $PR + QR = 25$ cm and $PQ = 5$ cm. Determine the values of $\sin P$, $\cos P$ and $\tan P$.

Solution: Let $QR = x$ cm. Then $PR = (25 - x)$ cm. PR is the hypotenuse, so

$$PR^2 = PQ^2 + QR^2$$

$$(25 - x)^2 = 25 + x^2$$

$$625 - 50x + x^2 = 25 + x^2$$

$$50x = 600, \text{ so } x = 12.$$

So $QR = 12$ cm and $PR = 13$ cm. For angle

$$\sin P = QR/PR = 12/13, \cos P = PQ/PR = 5/13$$

Example 5: Using both acute angles (NCERT Exercise 8.1, Q11)

Question: In triangle ABC, right-angled at C, $\sin A = 3/5$. Find $\cos A$, $\sin C$, $\cos C$, $\tan A$, $\tan C$, $\sec A$, $\sec C$, $\csc A$, $\csc C$.

Solution: $\tan A = 1/\sqrt{3} = BC/AB$. Let $BC = 1$ and $AB = \sqrt{3}$.

$$\sin A = BC/AB = 1/2, \cos A = AB/AC = \sqrt{3}/2$$

$$(i) \sin A \cos C + \cos A \sin C = (1/2)(1/2) + (\sqrt{3}/2)(\sqrt{3}/2) = 1/4 + 3/4 = 1$$

$$(ii) \cos A \cos C - \sin A \sin C = (\sqrt{3}/2)(1/2) - (1/2)(\sqrt{3}/2) = \sqrt{3}/4 - \sqrt{3}/4 = 0$$



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Example 6: Finding sides from an angle (NCERT Example 6)

Question: In ΔABC , right-angled at B, $AB = 5$ cm and $\angle ACB = 30^\circ$. Determine the lengths of the sides BC and AC.

Solution: With respect to angle C, AB is the opposite side and BC is the adjacent side. So

$AB/BC = \tan C$, that is $5/BC = \tan 30^\circ = 1/\sqrt{3}$, which gives $BC = 5\sqrt{3}$ cm.

For AC, use $\sin C = AB/AC$: $1/2 = 5/AC$, so $AC = 10$ cm.

Check by the Pythagoras theorem: $AC = \sqrt{(5^2 + (5\sqrt{3})^2)} = \sqrt{(25 + 75)} = \sqrt{100} = 10$ cm.

Example 7: Finding angles from sides (NCERT Example 7)

Question: In ΔPQR , right-angled at Q, $PQ = 3$ cm and $PR = 6$ cm. Determine $\angle QPR$ and $\angle PRQ$.

Solution: PQ is opposite to angle R and PR is the hypotenuse. So $\sin R = PQ/PR = 3/6 = 1/2$, which gives $\angle PRQ = 30^\circ$.

The angles of the triangle add up to 180° and $\angle PQR = 90^\circ$, so $\angle QPR = 60^\circ$.

Example 8: Evaluating with standard values

Question: Evaluate the following: (ii) $2 \tan 30^\circ - \tan^2 45^\circ / (\sin^2 30^\circ + \cos^2 30^\circ)$

Solution:

$$(ii) \ 2(1/\sqrt{3})^2 + (\sqrt{3}/2)^2 - (\sqrt{3}/2)^2 = 2 + 3/4 - 3/4 = 2$$

$$(v) \text{ Numerator} = 5(1/2)^2 + 4(2/\sqrt{3})^2 - 1^2 = 5/4 + 16/3 - 1 = 17/12$$

$$\text{Denominator} = (1/2)^2 + (\sqrt{3}/2)^2 = 1/4 + 3/4 = 1$$

So the value is $17/12$.

Example 9: Two angles from two equations

Question: If $\tan (A + B) = \sqrt{3}$ and $\tan (A - B) = 1/\sqrt{3}$, find the values of A and B.

Solution: $\tan (A + B) = \sqrt{3} = \tan 60^\circ$, so $A + B = 60^\circ$ (1)



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$$\tan (A - B) = 1/\sqrt{3} = \tan 30^\circ, \text{ so } A - B = 30^\circ \quad (2)$$

Adding (1) and (2): $2A = 90^\circ$, so $A = 45^\circ$. Then $B = 60^\circ - 45^\circ = 15^\circ$.

Example 10: A short identity proof (NCERT Example 10)

Question: Prove that $\sec A (1 - \sin A)(\sec A + \tan A) = 1$.

Solution:

$$\text{LHS} = (1/\cos A)(1 - \sin A)(1/\cos A + \sin A/\cos A)$$

$$= (1 - \sin A)(1 + \sin A) / \cos^2 A$$

$$= (1 - \sin^2 A) / \cos^2 A$$

$$= \cos^2 A / \cos^2 A = 1 = \text{RHS}$$

Example 11: Identity with a square

Question: Prove that $(\operatorname{cosec} \theta - \cot \theta)^2 =$

Solution:

$$\text{LHS} = (1/\sin \theta - \cos \theta/\sin \theta)^2 = (1 - \cos \theta)^2 / \sin^2 \theta$$

$$= (1 - \cos \theta)^2 / (1 - \cos^2 \theta)$$

$$= (1 - \cos \theta)(1 - \cos \theta) / [(1 - \cos \theta)(1 + \cos \theta)]$$

$$= (1 - \cos \theta) / (1 + \cos \theta) = \text{RHS}$$

Example 12: Using a named identity

Question: Prove that $(\cos A - \sin A + 1)/(\cos A + \sin A - 1) = \operatorname{cosec}^2 A = 1 + \cot^2 A$.

Solution: Divide the numerator and the denominator by $\cos A$.

$$\text{LHS} = (\cot A - 1 + \operatorname{cosec} A)/(\cot A + 1 - \operatorname{cosec} A)$$

In the numerator, replace 1 by $\operatorname{cosec}^2 A - \cot^2 A$:



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$$\text{Numerator} = (\operatorname{cosec} A + \cot A) - (\operatorname{cosec}^2 A - \cot^2 A)$$

$$= (\operatorname{cosec} A + \cot A) - (\operatorname{cosec} A + \cot A)(\operatorname{cosec} A - \cot A)$$

$$= (\operatorname{cosec} A + \cot A)(1 - \operatorname{cosec} A + \cot A)$$

The bracket $(1 - \operatorname{cosec} A + \cot A)$ is exactly the denominator. So

$$\text{LHS} = (\operatorname{cosec} A + \cot A)(1 - \operatorname{cosec} A + \cot A)/(\cot A + 1 - \operatorname{cosec} A) = \operatorname{cosec} A + \cot A = \text{RHS}$$

Competency-Based Questions (with answers)

1. Case-based: The wheelchair ramp

A school builds a ramp to its library door. The ramp surface makes a right triangle with the ground, with the right angle between the ramp and the ground. The ramp surface makes with the ground.

(i) Find the horizontal distance covered by the ramp has the same angle θ but a vertical rise of 5/12.

Answer: (i) Horizontal distance = $\sqrt{13^2 - 5^2} = 12$ m.

(ii) The rise is opposite to θ and the ground is adjacent to θ . So, $\tan \theta = \frac{5}{12}$.

(iii) The ratios depend only on the angle, so $\frac{12}{5} = \frac{26}{5.2}$. $26/5 = 5.2$ m.

2. Case-based: The kite string

Riya flies a kite. The taut string from her hand to the kite is 26 m. The horizontal line through her hand, and the kite string form a right triangle. Treat the string as a straight line.

(i) Name the side of the right triangle that is adjacent to θ .

(iii) Find the horizontal distance from her hand to the kite.



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Answer: (i) The string is the hypotenuse, as it faces the right angle between the vertical and the horizontal.

(ii) $\sin 60^\circ = 30/\text{string}$, so $\sqrt{3}/2 = 30/L$ and $L = 60/\sqrt{3} = 20\sqrt{3}$ m.

(iii) $\tan 60^\circ = 30/d$, so $\sqrt{3} = 30/d$ and $d = 30/\sqrt{3} = 10\sqrt{3}$ m.

3. Source-based: From jya to sine

Read the passage: "The first use of the idea of sine in the way we use it today was in the work Aryabhatiyam by Aryabhata, in A.D. 500. Aryabhata used the word ardha-jya for the half-chord, which was shortened to jya or jiva in due course. An English Professor of astronomy Edmund Gunter (1581 to 1626), first used the abbreviated notation 'sin'. The cosine function arose from the need to compute the sine of the complementary angle. Aryabhata called it kotijya."

(i) Who first used the abbreviation "sin"? (ii) In triangle ABC right-angled at B, angles A and C are complementary. Show that $\cos A = \sin C$.

Answer: (i) Edmund Gunter, an English professor.

(ii) $\cos A = AB/AC$ (adjacent to A over hypotenuse).
Hence $\cos A = \sin C$.

(iii) $\cos A = \sin C = 0.6$.

4. Assertion-Reason

Assertion (A): For an acute angle A, the value of $\sin A$ is always less than 1.

Reason (R): The hypotenuse is the longest side of a right-angled triangle.

- (a) Both A and R are true and R is the correct explanation of A.
- (b) Both A and R are true but R is not the correct explanation of A.
- (c) A is true but R is false.
- (d) A is false but R is true.

Answer: (d). $\sin A = \text{opposite/hypotenuse}$ is always less than 1. $4/3$ is more than 1, so A is false.

5. Assertion-Reason

Assertion (A): $\sin 30^\circ = \cos 60^\circ$.



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Reason (R): In a right triangle, the side opposite one acute angle is the side adjacent to the other acute angle.

- (a) Both A and R are true and R is the correct explanation of A.
- (b) Both A and R are true but R is not the correct explanation of A.
- (c) A is true but R is false.
- (d) A is false but R is true.

Answer: (a). Both values equal $1/2$. In the half equilateral triangle, 30° and 60° are the two acute angles; the side BD is opposite to 30° and adjacent to 60° , so BD/AB is at once $\sin 30^\circ$ and $\cos 60^\circ$. R explains A.

6. Assertion-Reason

Assertion (A): $1 + \tan^2 A = \sec^2 A$ is true for $A = 90^\circ$.

Reason (R): $\tan 90^\circ$ and $\sec 90^\circ$ are not defined.

- (a) Both A and R are true and R is the correct explanation of A.
- (b) Both A and R are true but R is not the correct explanation of A.
- (c) A is true but R is false.
- (d) A is false but R is true.

Answer: (d). $\tan 90^\circ = \sin 90^\circ / \cos 90^\circ = 1/0$ cannot be applied at 90° . It holds only for acute angles.

7. Error analysis: The wrong expansion

A student writes: " $\sin (30^\circ + 60^\circ) = \sin 30^\circ + \sin 60^\circ$ ".

- (i) Find the correct value of $\sin (30^\circ + 60^\circ)$.

Answer: (i) $\sin (30^\circ + 60^\circ) = \sin 90^\circ = 1$. The student's answer is more than 1, which a sine can never be.

- (ii) No. A single counter-example, such as $\sin (30^\circ + 60^\circ) \neq \sin 30^\circ + \sin 60^\circ$, is enough to show the statement is false. This is NCERT Exercise 8.2, Q4(i).

8. Competency MCQ: Which value

For an acute angle A, which one of these is true?



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(a) $\cos A = 1.2$ (b) $\operatorname{cosec} A = 0.8$ (c) $\sec A = 12/5$ (d) $\sin A = \sqrt{5}/2$

Answer: (c). $\cos A$ and $\sin A$ cannot exceed 1: 1.2 is too big, and $\sqrt{5}/2$ is about 1.118, also too big. $\operatorname{cosec} A$ cannot be less than 1, so 0.8 is impossible. $\sec A = 12/5$ means hypotenuse 12 and adjacent side 5, which is a real right triangle with opposite side $\sqrt{(144 - 25)} = \sqrt{119}$. This matches NCERT Exercise 8.1, Q11(ii).

Important Questions for Board Exams

1-Mark Questions

Q1. Choose the correct option: $9 \sec^2 A - 9 \tan^2 A =$ (A) 1 (B) 9 (C) 8 (D) 0

Answer: (B) 9, because $9(\sec^2 A - \tan^2 A) = 9 \times 1 = 9$.

Q2. Choose the correct option: $(1 - \tan^2 45^\circ)$

Answer: (D) 0, because $\tan 45^\circ = 1$ makes

Q3. Choose the correct option: $\sin 2A = 2$

Answer: (A) 0° . Both sides equal 0. At 30° and 60° fail the same way.

Q4. Choose the correct option: $(1 + \tan^2 A)$

Answer: (D) $\tan^2 A$, because $\sec^2 A / \operatorname{cosec} A = \tan^2 A$

Q5. State whether true or false and justify

Answer: True. $\cot 0^\circ = \cos 0^\circ / \sin 0^\circ = 1/0$

2-Mark Questions

Q6. If $\sin A = 3/4$, calculate $\cos A$ and $\tan A$

Answer: Let the opposite side be $3k$ and the hypotenuse be $4k$. So $\cos A = \sqrt{7}/4$ and $\tan A = 3/\sqrt{7}$.



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Q7. Evaluate: $\sin 60^\circ \cos 30^\circ + \sin 30^\circ \cos 60^\circ$

Answer: $(\sqrt{3}/2)(\sqrt{3}/2) + (1/2)(1/2) = 3/4 + 1/4 = 1.$

Q8. If $\cot \theta = 7/8$, evaluate: (i) $(1 + \sin \theta)(1 - \sin \theta)/[(1 + \cos \theta)(1 - \cos \theta)]$ (ii) $\cot^2 \theta$

Answer: (i) The expression is $(1 - \sin^2 \theta)/(1 - \cos^2 \theta) = \cos^2 \theta / \sin^2 \theta = \cot^2 \theta = 49/64$. (ii) $\cot^2 \theta = (7/8)^2 = 49/64$.

Q9. Choose the correct option and justify: $2 \tan 30^\circ / (1 + \tan^2 30^\circ) =$ (A) $\sin 60^\circ$ (B) $\cos 60^\circ$ (C) $\tan 60^\circ$ (D) $\sin 30^\circ$

Answer: $2 \tan 30^\circ = 2/\sqrt{3}$ and $1 + \tan^2 30^\circ = 1 + 1/3 = 4/3$. The value is $(2/\sqrt{3}) \times (3/4) = 3/(2\sqrt{3}) = \sqrt{3}/2 = \sin 60^\circ$. Option (A).

3-Mark Questions

Q10. If $\angle A$ and $\angle B$ are acute angles such that

Answer: A and B are any two acute angles (see NCERT Example 2). Let triangle ACD be right-angled at E with acute angle B.

$\cos A = AC/AD$ and $\cos B = BE/BF$. Since $\angle A = \angle B$, we can say. (1)

By the Pythagoras theorem, $CD = \sqrt{AD^2 - AC^2}$. Also, $CD/EF = k$. (2)

From (1) and (2), $AC/BE = AD/BF = CD/EF$. By the AA criterion, and therefore $\angle A = \angle B$.

Q11. Evaluate: $\cos 45^\circ / (\sec 30^\circ + \operatorname{cosec} 30^\circ)$

Answer: $\sec 30^\circ + \operatorname{cosec} 30^\circ = 2/\sqrt{3} + 2$. Multiply top and bottom by $(3\sqrt{2} - \sqrt{6})/8$.

Q12. Prove that $(1 + \sec A)/\sec A = \sin^2 A / (1 - \sin^2 A)$



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Answer: LHS = $(1 + 1/\cos A)/(1/\cos A) = \cos A + 1$. RHS = $(1 - \cos^2 A)/(1 - \cos A) = (1 - \cos A)(1 + \cos A)/(1 - \cos A) = 1 + \cos A$. LHS = RHS.

Q13. Prove that $\sqrt{(1 + \sin A)/(1 - \sin A)} = \sec A + \tan A$.

Answer: Multiply inside the root by $(1 + \sin A)/(1 + \sin A)$: LHS = $\sqrt{[(1 + \sin A)^2/(1 - \sin^2 A)]} = \sqrt{[(1 + \sin A)^2/\cos^2 A]} = (1 + \sin A)/\cos A$, taking the positive root since A is acute. This equals $1/\cos A + \sin A/\cos A = \sec A + \tan A = \text{RHS}$.

5-Mark Questions

Q14. Prove that $\tan \theta/(1 - \cot \theta) + \cot \theta/(1 - \tan \theta) = 1 + \sec \theta \operatorname{cosec} \theta$. [Write the expression in terms of $\sin \theta$ and $\cos \theta$.]

Answer: Write $s = \sin \theta$ and $c = \cos \theta$.

First term = $(s/c) / [(s - c)/s] = s^2/[c(s - c)]$

Second term = $(c/s) / [(c - s)/c] = c^2/[s(c - s)]$

LHS = $[s^3 - c^3]/[sc(s - c)] = (s - c)(s^2 + sc + c^2)/[sc(s - c)]$

$1/(\sin \theta \cos \theta) = \sec \theta \operatorname{cosec} \theta$, so LHS = $1 + \sec \theta \operatorname{cosec} \theta = \text{RHS}$

Q15. Prove that $(\sin \theta - \cos \theta + 1)/(\sin \theta + \cos \theta - 1) = 1 + \tan^2 \theta$.

Answer: Divide the numerator and denominator by $\cos \theta$

LHS = $(\tan \theta - 1 + \sec \theta)/(\tan \theta + 1 - \sec \theta)$

Multiply top and bottom by $(\tan \theta - \sec \theta)$

$= [(\tan \theta + \sec \theta - 1)(\tan \theta - \sec \theta)] / [(\tan \theta + 1 - \sec \theta)(\tan \theta - \sec \theta)]$

The numerator is $(\tan^2 \theta - \sec^2 \theta) - (\tan \theta - \sec \theta)$

So LHS = $-(1 + \tan \theta - \sec \theta) / [(\tan \theta - \sec \theta)(\tan \theta + 1 - \sec \theta)] = \text{RHS}$. (This is NCERT Example 1)

Q16. Prove that $(\sin A + \operatorname{cosec} A)^2 + (\cos A + \sec A)^2 = 2(\sec^2 A + \operatorname{cosec}^2 A)$



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Answer: Expand each square:

$$(\sin A + \operatorname{cosec} A)^2 = \sin^2 A + \operatorname{cosec}^2 A + 2 \sin A \operatorname{cosec} A = \sin^2 A + \operatorname{cosec}^2 A + 2$$

$$(\cos A + \sec A)^2 = \cos^2 A + \sec^2 A + 2$$

$$\text{LHS} = (\sin^2 A + \cos^2 A) + \operatorname{cosec}^2 A + \sec^2 A + 4 = 1 + (1 + \cot^2 A) + (1 + \tan^2 A) + 4 = 7 + \tan^2 A + \cot^2 A = \text{RHS}.$$

Common Mistakes and Examiner Tips

- Mixing up opposite and adjacent.** Students often label sides once and use the same labels for the other angle. Fix: before writing any ratio, say which angle you are working with and mark its opposite side. For angle C in triangle ABC (right angle at B), AB is the opposite side and BC is the adjacent side.
- Using the hypotenuse as the adjacent** adjacent side is the arm of the angle the
- Treating $\sin A$ as $\sin \times A$.** Writing $\sin 2A$ wrong. Fix: $\sin A$ is one symbol for one $30^\circ = 1$.
- Splitting $\sin(A + B)$.** $\sin(A + B) = \sin A$ angle $A + B$ first, then take its sine.
- Reading $\sin^{-1} A$ as $\operatorname{cosec} A$.** $\operatorname{cosec} A =$ else (sine inverse). Fix: write $1/\sin A$ or
- Keeping the negative root.** When the P write $AB = \pm 2\sqrt{2} k$. Fix: a side is a length ratios are positive.
- Swapping the sin and cos rows.** Writin from 0 to 1, so the smaller angle has the
- Calling $\tan 90^\circ$ "infinity" or 0.** Fix: writ $90^\circ = 0$. The same wording is needed f
- Ignoring the range of an identity.** $1 + \tan = \operatorname{cosec}^2 A$ fails at 0° . Fix: learn each ide
- Working on both sides of an identity a** what you are trying to prove. Fix: start f says "simplify LHS and RHS separately", as in NCERT Exercise 8.3 Q4(iv) and (ix).



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Quick Revision Points

- Trigonometry studies the relationships between the sides and angles of a triangle; the word means "three sides measure".
- Opposite and adjacent depend on the angle chosen. The hypotenuse is always the side facing the right angle.
- $\sin A = \text{opposite/hypotenuse}$, $\cos A = \text{adjacent/hypotenuse}$, $\tan A = \text{opposite/adjacent}$.
- $\operatorname{cosec} A = 1/\sin A$, $\sec A = 1/\cos A$, $\cot A = 1/\tan A$.
- $\tan A = \sin A/\cos A$ and $\cot A = \cos A/\sin A$.
- In a right triangle, $\sin$ of one acute angle equals $\cos$ of the other.
- $\sin^2 A$ means $(\sin A)^2$; $\sin^{-1} A$ is a different idea from $\operatorname{cosec} A$.
- Ratios depend only on the angle, by AA similarity the size of the triangle does not matter.
- Given one ratio, call the two sides marked x and y .
- $\sin A$ and $\cos A$ lie between 0 and 1; $\sec A$ and $\operatorname{cosec} A$ can have negative values.
- 45° comes from an isosceles right triangle.
- 30° and 60° come from half an equilateral triangle.
- $\sin$ row: 0, $1/2$, $1/\sqrt{2}$, $\sqrt{3}/2$, 1. $\cos$ row: 1, $\sqrt{3}/2$, $1/\sqrt{2}$, $1/2$, 0.
- $\tan$ row: 0, $1/\sqrt{3}$, 1, $\sqrt{3}$, not defined.
- Not defined: $\tan 90^\circ$, $\sec 90^\circ$, $\cot 0^\circ$, $\operatorname{cosec} 0^\circ$.
- $\sin^2 A + \cos^2 A = 1$ for $0^\circ \leq A \leq 90^\circ$.
- $1 + \tan^2 A = \sec^2 A$ for $0^\circ \leq A < 90^\circ$.
- $\cot^2 A + 1 = \operatorname{cosec}^2 A$ for $0^\circ < A \leq 90^\circ$.
- $(\sec A - \tan A)(\sec A + \tan A) = 1$ and $(\operatorname{cosec} A - \cot A)(\operatorname{cosec} A + \cot A) = 1$.
- To prove an identity, convert to $\sin$ and $\cos$.



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Weightage in Board Exams

Introduction to Trigonometry belongs to the Chapter 9, Some Applications of Trigonometry. Check the current CBSE course structure for the

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marks given to the unit. Within it, this chapter is assessed in a predictable way.

Question type	What is usually asked
MCQ and Assertion-Reason	Standard values; “not defined” cases; possible and impossible values of a ratio; ranges of the identities; one-step simplifications such as $9 \sec^2 A - 9 \tan^2 A$
Short answers	All ratios from one given ratio; evaluating an expression with standard values; finding two angles from two equations
Long answers	Proving an identity, often with a hint to write it in sin and cos or to use a named identity
Case-based	A real right-triangle situation (ramp, ladder, string) split into parts: name the sides, find a ratio, find a missing length

Preparation plan: know Table 8.1 without e
ten parts of Exercise 8.3 Q4, and revise th



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