

# SOME APPLICATIONS OF TRIGONOMETRY

## CHAPTER 9 - CLASS 10 MATHEMATICS

CBSE Board Exam 2025-26

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COMPREHENSIVE STUDY MATERIAL - HEIGHTS AND DISTANCES

### CHAPTER AT A GLANCE

#### Chapter Overview:







- **Chapter Name:** Some Applications of Trigonometry
- **Main Topic:** Heights and Distances
- **Weightage in Board Exam:** 8-12 marks
- **Difficulty Level:** Medium to High
- **Question Types:** 2 marks, 3 marks, 5 marks
- **Prerequisites:** Trigonometric ratios, Standard angles
- **Time Required:** 15-20 days for complete mastery
- **Practice Problems Needed:** Minimum 100 problems

## INTRODUCTION

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### Real-Life Applications:

Trigonometry is not just a mathematical concept but a powerful tool used in real life to solve practical problems. This chapter explores how trigonometric ratios help us calculate:

-  **Heights of buildings and towers** without climbing them
-  **Widths of rivers** without crossing them
-  **Altitude of flying objects** like airplanes and kites
-  **Heights of mountains** from a distance
-  **Distances between ships** and lighthouses
-  **Engineering calculations** for construction

## KEY DEFINITIONS (MEMORIZE THESE!)

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### 1. Line of Sight:

The **line of sight** is the straight line drawn from the eye of an observer to the point being viewed on the object.

*Think of it as: An imaginary straight line connecting your eye to the object you're looking at.*

### 2. Horizontal Level:

The **horizontal level** is an imaginary horizontal line passing through the eye of the observer, parallel to the ground.

*Think of it as: Looking straight ahead without tilting your head up or down.*

### 3. Angle of Elevation:

The **angle of elevation** is the angle formed between the line of sight and the horizontal level when the object is **ABOVE** the horizontal level.

**Key Point:** We **RAISE our head** to look at the object.

*Example: Looking up at the top of a building, bird flying in sky, top of a tree.*

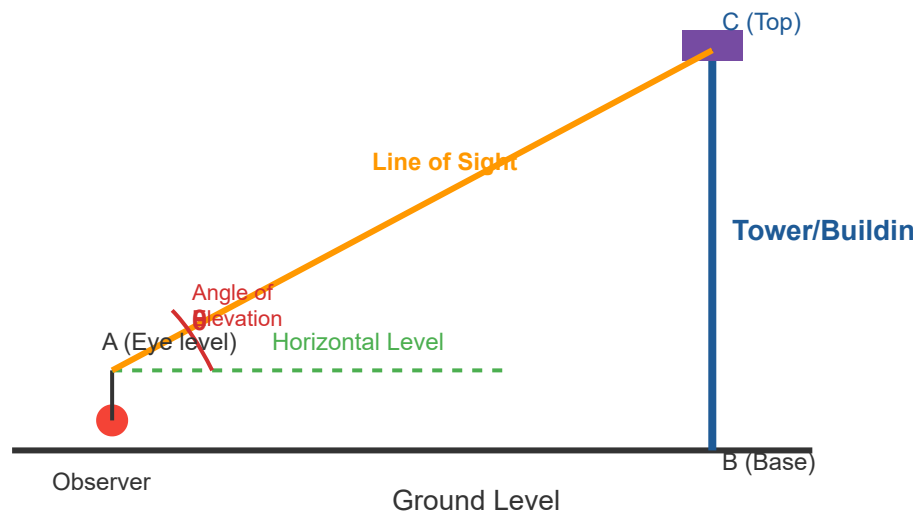
### 4. Angle of Depression:

The **angle of depression** is the angle formed between the line of sight and the horizontal level when the object is **BELOW** the horizontal level.

**Key Point:** We **LOWER our head** to look at the object.

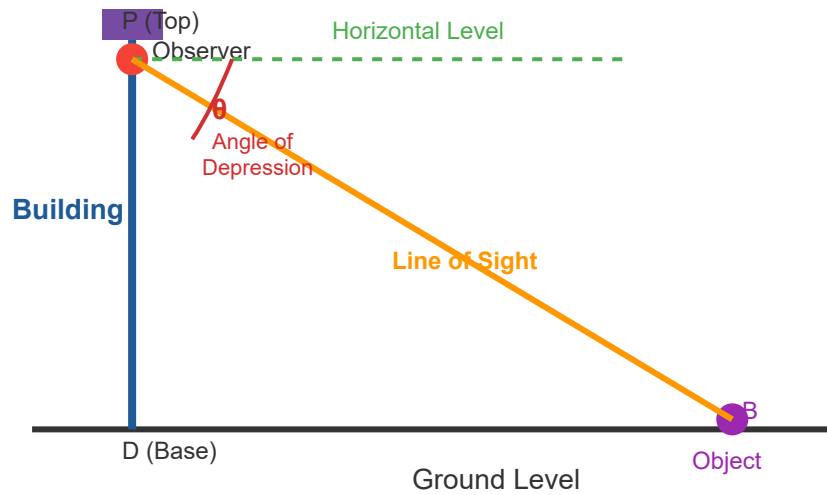
*Example: Looking down from a balcony, viewing a boat from a lighthouse, looking at ground from an airplane.*

Diagram 1: Angle of Elevation



**Note:** Observer at A looks UP to see point C. Angle CAB = Angle of Elevation ( $\theta$ )

## Diagram 2: Angle of Depression



**Note:** Observer at P looks DOWN to see point B. Angle of depression =  $\theta$

## ⚡ SUPER IMPORTANT THEOREM

🔥 **GOLDEN RULE - MUST REMEMBER!** 🔥

**ANGLE OF ELEVATION = ANGLE OF DEPRESSION**

(When measured from the same horizontal line using alternate angles)

## Why are they equal?

**Reason:** The horizontal line through the observer's eye is parallel to the ground level. The line of sight acts as a transversal cutting these parallel lines.

**By alternate angles theorem:** Angle of elevation from ground = Angle of depression from height

💡 **Exam Tip:** This property is used in 80% of angle of depression problems!



# STANDARD RIGHT TRIANGLE APPROACH

## Step-by-Step Method to Solve ANY Height-Distance Problem:

### 1. Step 1: Draw a Clear Diagram

- Draw the scenario exactly as described
- Mark the right angle (usually at the base)
- Label all given information
- Mark what you need to find with a question mark (?)

### 2. Step 2: Identify the Right Triangle

- Find which triangle contains your required measurement
- Ensure it's a right-angled triangle

### 3. Step 3: Identify Given Information

- Angle given (angle of elevation/depression)
- One side given (height, distance, etc.)
- What you need to find (height, distance, etc.)

### 4. Step 4: Choose Correct Trigonometric Ratio

- Identify the sides relative to the given angle:
- - **Perpendicular (P)**: Side opposite to the angle
- - **Base (B)**: Side adjacent to the angle
- - **Hypotenuse (H)**: Side opposite to right angle
- Choose ratio from:  $\sin \theta = P/H$ ,  $\cos \theta = B/H$ ,  $\tan \theta = P/B$

### 5. Step 5: Form Equation and Solve

- Write the trigonometric equation
- Substitute known values
- Solve for unknown

**6. Step 6: Add/Subtract Heights if Required**

- If observer has height, add to calculated height
- If measuring to a point not at top, subtract appropriately

**7. Step 7: Write Final Answer with Units**

- Always include units (m, km, etc.)
- Round to appropriate decimal places if specified

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## WHICH TRIGONOMETRIC RATIO TO USE?

### Quick Selection Guide:

Given Information	To Find	Use Ratio	Formula
Angle + Height	Distance	$\tan \theta$ or $\cot \theta$	$\tan \theta = \text{Height/Distance}$
Angle + Distance	Height	$\tan \theta$ or $\cot \theta$	$\tan \theta = \text{Height/Distance}$
Angle + Height	Hypotenuse (ladder, rope)	$\sin \theta$ or $\text{cosec } \theta$	$\sin \theta = \text{Height/Hypotenuse}$
Angle + Distance	Hypotenuse	$\cos \theta$ or $\text{sec } \theta$	$\cos \theta = \text{Distance/Hypotenuse}$
Two angles + one measurement	Other measurements	Form two equations using $\tan$	Use $\tan$ for both triangles

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### **Pro Tips for Choosing Ratios:**

- **Tip 1:** When height and distance are involved → Use  $\tan \theta$  or  $\cot \theta$
- **Tip 2:** When ladder/rope/cable length involved → Use  $\sin \theta$  or  $\cos \theta$
- **Tip 3:** Prefer  $\tan$  and  $\cot$  over others as they directly relate height and distance
- **Tip 4:** If you get  $\sin$  or  $\cos$  in denominator, use  $\operatorname{cosec}$  or  $\operatorname{sec}$  instead
- **Tip 5:** For two-observer or two-position problems, set up two equations and solve simultaneously



## SOLVED EXAMPLES (NCERT BASED)

### Example 1: Tower Height Problem (Basic Level)

**Question:** A tower stands vertically on the ground. From a point on the ground, which is 15 m away from the foot of the tower, the angle of elevation of the top of the tower is found to be  $60^\circ$ . Find the height of the tower.

**Solution:**

#### Step 1: Draw diagram

Let AB = tower (height = h m)

Let C = point of observation on ground

Given: BC = 15 m,  $\angle ACB = 60^\circ$

To find: AB = ?

#### Step 2: Identify the right triangle

$\triangle ABC$  is right-angled at B

#### Step 3: Choose trigonometric ratio

We have: Base (BC) = 15 m, Angle =  $60^\circ$ , Need: Perpendicular (AB)

Use:  $\tan \theta = \text{Perpendicular/Base}$

#### Step 4: Form equation

$$\tan 60^\circ = AB/BC$$

$$\sqrt{3} = AB/15$$

$$AB = 15\sqrt{3} \text{ m}$$

#### Step 5: Calculate value

$$AB = 15 \times 1.732 = 25.98 \text{ m} \approx 26 \text{ m}$$

**Answer: Height of tower =  $15\sqrt{3}$  m or 26 m (approximately)**

## Example 2: Ladder Problem (NCERT Example 2)

**Question:** An electrician has to repair an electric fault on a pole of height 5 m. She needs to reach a point 1.3 m below the top of the pole to undertake the repair work. What should be the length of the ladder that she should use which, when inclined at an angle of  $60^\circ$  to the horizontal, would enable her to reach the required position? Also, how far from the foot of the pole should she place the foot of the ladder? (Take  $\sqrt{3} = 1.73$ )

**Solution:**

### Step 1: Understand the problem

Total pole height = 5 m

Point to reach = 1.3 m below top

Height to reach (BD) =  $5 - 1.3 = 3.7$  m

Angle with ground =  $60^\circ$

To find: (i) Length of ladder (BC), (ii) Distance from pole (DC)

### Step 2: Find length of ladder (BC)

In right triangle BDC:

$$\sin 60^\circ = \frac{BD}{BC}$$

$$\frac{\sqrt{3}}{2} = \frac{3.7}{BC}$$

$$BC = \frac{(3.7 \times 2)}{\sqrt{3}} = \frac{7.4}{\sqrt{3}}$$

$$BC = \frac{7.4}{1.73} = 4.28 \text{ m}$$

### Step 3: Find distance from pole (DC)

$$\cot 60^\circ = \frac{DC}{BD}$$

$$1/\sqrt{3} = DC/3.7$$

$$DC = 3.7/\sqrt{3} = 3.7/1.73 = 2.14 \text{ m}$$

**Answer:**

(i) Length of ladder = 4.28 m

(ii) Distance from pole = 2.14 m

### Example 3: Observer and Chimney (NCERT Example 3)

**Question:** An observer 1.5 m tall is 28.5 m away from a chimney. The angle of elevation of the top of the chimney from her eyes is  $45^\circ$ . What is the height of the chimney?

**Solution:**

**Step 1: Draw diagram with labels**

Let AB = chimney (height = h m)

CD = observer (height = 1.5 m)

DE = CB = 28.5 m (horizontal distance)

$\angle ADE = 45^\circ$  (angle of elevation from eyes)

BE = CD = 1.5 m (observer's height)

**Step 2: Find AE (part above eye level)**

In right triangle ADE:

$$\tan 45^\circ = AE/DE$$

$$1 = AE/28.5$$

$$AE = 28.5 \text{ m}$$

**Step 3: Find total height AB**

$$AB = AE + BE$$

$$AB = 28.5 + 1.5$$

$$AB = 30 \text{ m}$$

**Answer: Height of chimney = 30 m**

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### Example 4: Building and Flagstaff (NCERT Example 4)

**Question:** From a point P on the ground, the angle of elevation of the top of a 10 m tall building is  $30^\circ$ . A flag is hoisted at the top of the building and the angle of elevation of the top of the flagstaff from P is  $45^\circ$ . Find the length of the flagstaff and the distance of the building from point P. (Take  $\sqrt{3} = 1.732$ )

**Solution:**

#### Step 1: Understand the setup

$$AB = \text{building} = 10 \text{ m}$$

$$BD = \text{flagstaff} = x \text{ m (to find)}$$

$$\angle APB = 30^\circ \text{ (angle to top of building)}$$

$$\angle APD = 45^\circ \text{ (angle to top of flagstaff)}$$

$$PA = \text{distance from building (to find)}$$

$$AD = AB + BD = (10 + x) \text{ m}$$

#### Step 2: From right triangle PAB

$$\tan 30^\circ = AB/PA$$

$$1/\sqrt{3} = 10/PA$$

$$PA = 10\sqrt{3} \text{ m}$$

$$PA = 10 \times 1.732 = 17.32 \text{ m}$$

#### Step 3: From right triangle PAD

$$\tan 45^\circ = AD/PA$$

$$1 = (10 + x)/(10\sqrt{3})$$

$$10\sqrt{3} = 10 + x$$

$$x = 10\sqrt{3} - 10$$

$$x = 10(\sqrt{3} - 1)$$

$$x = 10(1.732 - 1)$$

$$x = 10 \times 0.732 = 7.32 \text{ m}$$

**Answer:**

(i) Length of flagstaff = 7.32 m

(ii) Distance from building = 17.32 m

## Example 5: Shadow of Tower - Two Angles (NCERT Example 5)

**Question:** The shadow of a tower standing on a level ground is found to be 40 m longer when the Sun's altitude is  $30^\circ$  than when it is  $60^\circ$ . Find the height of the tower.

**Solution:**

**Step 1: Setup with two positions**

Let AB = tower = h m

BC = shadow when angle =  $60^\circ$  = x m

BD = shadow when angle =  $30^\circ$  = (x + 40) m

**Step 2: From right triangle ABC ( $60^\circ$  angle)**

$$\tan 60^\circ = AB/BC$$

$$\sqrt{3} = h/x$$

$$h = x\sqrt{3} \dots \text{(equation 1)}$$

**Step 3: From right triangle ABD ( $30^\circ$  angle)**

$$\tan 30^\circ = AB/BD$$

$$1/\sqrt{3} = h/(x + 40)$$

$$h = (x + 40)/\sqrt{3} \dots \text{(equation 2)}$$

**Step 4: Equate both expressions**

$$x\sqrt{3} = (x + 40)/\sqrt{3}$$

$$3x = x + 40$$

$$2x = 40$$

$$x = 20 \text{ m}$$

**Step 5: Find height**

$$h = x\sqrt{3} = 20\sqrt{3} \text{ m}$$

$$h = 20 \times 1.732 = 34.64 \text{ m}$$

**Answer: Height of tower =  $20\sqrt{3}$  m or 34.64 m**

## Example 6: Angle of Depression Problem (NCERT Example 6)

**Question:** The angles of depression of the top and bottom of an 8 m tall building from the top of a multi-storeyed building are  $30^\circ$  and  $45^\circ$  respectively. Find the height of the multi-storeyed building and the distance between the two buildings.

**Solution:**

### Step 1: Setup the problem

Let PC = multi-storeyed building = h m

AB = 8 m tall building

Angle of depression to top (B) =  $30^\circ$

Angle of depression to bottom (A) =  $45^\circ$

Distance AC = BD = ?

PD = PC - DC = h - 8

### Step 2: Use angle of depression property

$\angle QPB = \angle PBD = 30^\circ$  (alternate angles)

$\angle QPA = \angle PAC = 45^\circ$  (alternate angles)

### Step 3: From right triangle PBD

$\tan 30^\circ = PD/BD$

$1/\sqrt{3} = (h - 8)/BD$

$BD = (h - 8)\sqrt{3} \dots$  (equation 1)

### Step 4: From right triangle PAC

$$\tan 45^\circ = PC/AC$$

$$1 = h/AC$$

$$AC = h \dots (\text{equation 2})$$

**Step 5: Since AC = BD**

$$h = (h - 8)\sqrt{3}$$

$$h = h\sqrt{3} - 8\sqrt{3}$$

$$h - h\sqrt{3} = -8\sqrt{3}$$

$$h(1 - \sqrt{3}) = -8\sqrt{3}$$

$$h = 8\sqrt{3}/(\sqrt{3} - 1)$$

$$h = 8\sqrt{3}(\sqrt{3} + 1)/[(\sqrt{3} - 1)(\sqrt{3} + 1)]$$

$$h = 8\sqrt{3}(\sqrt{3} + 1)/(3 - 1)$$

$$h = 8\sqrt{3}(\sqrt{3} + 1)/2$$

$$h = 4\sqrt{3}(\sqrt{3} + 1)$$

$$h = 4(3 + \sqrt{3})$$

$$h = 12 + 4\sqrt{3} \text{ m}$$

**Step 6: Calculate numerical value**

$$h = 12 + 4(1.732) = 12 + 6.928 = 18.928 \approx 19 \text{ m}$$

$$\text{Distance} = h = 19 \text{ m}$$

**Answer:**

$$\text{Height of multi-storeyed building} = 4(3 + \sqrt{3}) \text{ m} \approx 19 \text{ m}$$

$$\text{Distance between buildings} = 4(3 + \sqrt{3}) \text{ m} \approx 19 \text{ m}$$

## Example 7: River Width Problem (NCERT Example 7)

**Question:** From a point on a bridge across a river, the angles of depression of the banks on opposite sides of the river are  $30^\circ$  and  $45^\circ$  respectively. If the bridge is at a height of 3 m from the banks, find the width of the river.

**Solution:**

### Step 1: Setup

P = point on bridge at height 3 m

A and B = points on opposite banks

PD = 3 m (height of bridge)

Angle of depression to A =  $30^\circ$

Angle of depression to B =  $45^\circ$

Width of river AB = AD + DB = ?

### Step 2: From right triangle APD

$\angle A = 30^\circ$  (alternate angle)

$\tan 30^\circ = PD/AD$

$1/\sqrt{3} = 3/AD$

$AD = 3\sqrt{3}$  m

### Step 3: From right triangle PBD

$\angle B = 45^\circ$  (alternate angle)

$\tan 45^\circ = PD/BD$

$1 = 3/BD$

$$BD = 3 \text{ m}$$

**Step 4: Width of river**

$$AB = AD + BD$$

$$AB = 3\sqrt{3} + 3$$

$$AB = 3(\sqrt{3} + 1)$$

$$AB = 3(1.732 + 1)$$

$$AB = 3 \times 2.732 = 8.196 \text{ m}$$

**Answer: Width of river =  $3(\sqrt{3} + 1)$  m  $\approx$  8.2 m**

## COMMON MISTAKES TO AVOID

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### Mistake 1: Confusing Angle of Elevation and Depression

**Wrong:** Using angle of elevation when the problem mentions depression

**Correct:** Carefully read whether you're looking UP (elevation) or DOWN (depression)

**Solution:** Draw the diagram first - it makes it crystal clear!

## ✗ Mistake 2: Forgetting Observer's Height

**Wrong:** Not adding observer's height to the calculated height

**Example:** If observer is 1.5 m tall and calculated height is 28.5 m, total height = 30 m (not 28.5 m)

**Solution:** Always check if observer's height is mentioned and add/subtract as needed

## ✗ Mistake 3: Wrong Ratio Selection

**Wrong:** Using  $\sin \theta$  when you should use  $\tan \theta$

**Example:** When given distance and angle, to find height → use  $\tan$ , not  $\sin$

**Solution:** Identify which sides you have and which you need, then choose ratio accordingly

## ✗ Mistake 4: Incorrect Standard Values

**Wrong:**  $\tan 30^\circ = \sqrt{3}$  (This is WRONG!  $\tan 30^\circ = 1/\sqrt{3}$ )

**Common Errors:**

- $\tan 30^\circ = \sqrt{3}$  ✗ (Correct:  $\tan 30^\circ = 1/\sqrt{3}$ )
- $\tan 60^\circ = 1/\sqrt{3}$  ✗ (Correct:  $\tan 60^\circ = \sqrt{3}$ )
- $\sin 45^\circ = 1$  ✗ (Correct:  $\sin 45^\circ = 1/\sqrt{2}$ )

**Solution:** Memorize the table perfectly! Write it 50 times!

### ✗ Mistake 5: Not Simplifying $\sqrt{3}$ in Denominator

**Wrong:** Leaving answer as  $10/\sqrt{3}$

**Correct:** Rationalize to get  $10\sqrt{3}/3$

**Solution:** Always rationalize unless told otherwise

### ✗ Mistake 6: Calculation Errors with $\sqrt{3}$

**Wrong:** Using  $\sqrt{3} = 1.41$  (This is  $\sqrt{2}$ !)

**Correct:**  $\sqrt{3} = 1.732$  (or use exact form unless asked)

**Solution:** Remember:  $\sqrt{2} \approx 1.414$ ,  $\sqrt{3} \approx 1.732$

### ✗ Mistake 7: Missing Units in Final Answer

**Wrong:** Answer: Height = 30

**Correct:** Answer: Height = 30 m

**Solution:** Always write units in final answer

## ✗ Mistake 8: Not Converting to Same Units

**Wrong:** Using 1.5 km and 200 m together without conversion

**Correct:** Convert to same units:  $1.5 \text{ km} = 1500 \text{ m}$ , then calculate

**Solution:** Check all measurements are in same units before solving

## **100** FORMULA SHEET - MUST MEMORIZE!

### Essential Formulas:

S.No.	Situation	Formula	When to Use
1	Height and Distance	$\tan \theta = \text{Height/Distance}$	Most common formula - 80% problems
2	Height and Distance (inverse)	$\cot \theta = \text{Distance/Height}$	When easier to use cot
3	Height and Hypotenuse	$\sin \theta = \text{Height/Hypotenuse}$	Ladder, rope, cable problems
4	Distance and Hypotenuse	$\cos \theta = \text{Distance/Hypotenuse}$	When base and hypotenuse involved
5	Reciprocal of sin	$\operatorname{cosec} \theta = \text{Hypotenuse/Height}$	When sin appears in denominator

6	Reciprocal of cos	$\sec \theta =$ Hypotenuse/Distance	When cos appears in denominator
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## STANDARD ANGLES TABLE (MUST KNOW BY HEART!)

Ratio/Angle	0°	30°	45°	60°	90°
<b>sin <math>\theta</math></b>	0	1/2	1/√2	√3/2	1
<b>cos <math>\theta</math></b>	1	√3/2	1/√2	1/2	0
<b>tan <math>\theta</math></b>	0	1/√3	1	√3	∞ (undefined)
<b>cot <math>\theta</math></b>	∞ (undefined)	√3	1	1/√3	0
<b>sec <math>\theta</math></b>	1	2/√3	√2	2	∞ (undefined)
<b>cosec <math>\theta</math></b>	∞ (undefined)	2	√2	2/√3	1

## Memory Trick for Table:

**For sin  $\theta$ :** Think 0, 1, 2, 3, 4  $\rightarrow$  Divide by 2  $\rightarrow$  Take square root

- $\sin 0^\circ = \sqrt{(0/4)} = 0$
- $\sin 30^\circ = \sqrt{(1/4)} = 1/2$
- $\sin 45^\circ = \sqrt{(2/4)} = 1/\sqrt{2}$
- $\sin 60^\circ = \sqrt{(3/4)} = \sqrt{3}/2$
- $\sin 90^\circ = \sqrt{(4/4)} = 1$

**For cos  $\theta$ :** Reverse of sin (start from  $90^\circ$ )

**For tan  $\theta$ :**  $\tan = \sin/\cos$

## IMPORTANT THEOREMS & PROPERTIES

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### Property 1: Alternate Angles

When line of sight cuts two parallel lines (horizontal level and ground), alternate angles are equal.

**Consequence:** Angle of elevation from ground = Angle of depression from height

## Property 2: Pythagorean Theorem

In right triangle:  $(\text{Hypotenuse})^2 = (\text{Perpendicular})^2 + (\text{Base})^2$

**Use:** When you need to find third side from two given sides

## Property 3: Complementary Angles

In right triangle: Two acute angles are complementary (sum =  $90^\circ$ )

**Use:** If one angle is  $\theta$ , other is  $(90^\circ - \theta)$



## QUESTION PATTERNS IN BOARD EXAMS

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### Pattern 1: Single Object - Single Observer (2-3 marks)

**Type:** Find height given distance and angle, or vice versa

**Example:** Tower, building, tree height problems

**Approach:** One right triangle, one equation, solve using tan or cot

### **Pattern 2: Two Angles from Same Point (3-5 marks)**

**Type:** Shadow problems, flagstaff on building

**Example:** Shadow at two different sun angles

**Approach:** Two right triangles sharing one side, form two equations

### **Pattern 3: Angle of Depression Problems (3-5 marks)**

**Type:** Observer at height looking down

**Example:** From lighthouse, bridge, airplane

**Approach:** Use alternate angle property, then apply trigonometry

### **Pattern 4: Two Objects - Two Angles (5 marks)**

**Type:** Multi-storeyed building and short building

**Example:** Angles of depression to top and bottom

**Approach:** Two equations, solve simultaneously

### **Pattern 5: Moving Observer (3-5 marks)**

**Type:** Observer moves from one position to another

**Example:** Walking towards building, angle changes

**Approach:** Two positions, two triangles, find difference or sum

### **Pattern 6: Opposite Banks/Sides (3-5 marks)**

**Type:** Width of river, distance between two objects

**Example:** Bridge across river, angles to opposite banks

**Approach:** Find both distances separately, add for total width



## PRACTICE QUESTIONS (EXERCISE 9.1 TYPE)

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### Section A: Easy Level (2 Marks Each)

1. A tower is 50 m high. Find the distance from its foot where the angle of elevation of its top is  $45^\circ$ .
2. A ladder 15 m long reaches a window which is 9 m above the ground. Find the angle of elevation of the window from the foot of the ladder.
3. A tree casts a shadow 8 m long when the sun's altitude is  $60^\circ$ . Find the height of the tree.
4. From a point on the ground 20 m away from the foot of a tower, the angle of elevation of the top is  $30^\circ$ . Find the height of the tower.
5. A kite flying at a height of 75 m from the ground is attached to a string inclined at  $60^\circ$  to the horizontal. Find the length of the string.

## Section B: Medium Level (3 Marks Each)

6. A contractor plans to install a slide for children in a park. For the slide to be inclined at  $30^\circ$  to the ground and to reach a height of 2 m, what should be the length of the slide?
7. From the top of a 7 m high building, the angle of elevation of the top of a tower is  $60^\circ$  and the angle of depression of its foot is  $45^\circ$ . Find the height of the tower.
8. A tree breaks due to a storm and the broken part bends so that the top touches the ground making an angle of  $30^\circ$  with it. The distance from the foot of the tree to the point where the top touches the ground is 10 m. Find the height of the tree.
9. A man standing on the deck of a ship which is 10 m above water level, observes the angle of elevation of the top of a cliff as  $45^\circ$  and the angle of depression of its base as  $30^\circ$ . Find the height of the cliff.
10. The angles of elevation of the top of a tower from two points at distances  $a$  and  $b$  from the base and in the same straight line with it are complementary. Prove that the height of the tower is  $\sqrt{ab}$ .

### Section C: Difficult Level (5 Marks Each)

11. A vertical tower stands on a horizontal plane and is surmounted by a vertical flagstaff of height  $h$ . At a point on the plane, the angle of elevation of the bottom of the flagstaff is  $\alpha$  and that of the top of the flagstaff is  $\beta$ . Prove that the height of the tower is  $[h \tan \alpha / (\tan \beta - \tan \alpha)]$ .
12. From a point on a horizontal plane, the angle of elevation of the top of a tower is found to be  $\theta$ . On moving a distance  $d$  towards the foot of the tower, the angle becomes  $2\theta$ . Show that the height of the tower is  $[d / (2 \cos \theta)]$ .
13. A man on the top of a vertical tower observes a car moving at a uniform speed coming directly towards it. If it takes 12 minutes for the angle of depression to change from  $30^\circ$  to  $45^\circ$ , how soon after this will the car reach the tower? (Give your answer correct to nearest second.)
14. The angle of elevation of a cloud from a point  $h$  metres above a lake is  $\alpha$  and the angle of depression of its reflection in the lake is  $\beta$ . Prove that the height of the cloud above the lake is  $[h(\tan \beta + \tan \alpha) / (\tan \beta - \tan \alpha)]$ .
15. From an aeroplane vertically above a straight horizontal road, the angles of depression of two consecutive kilometer stones on opposite sides of the aeroplane are observed to be  $\alpha$  and  $\beta$ . Show that the height of the aeroplane above the road is  $[\tan \alpha \tan \beta / (\tan \alpha + \tan \beta)]$  km.



# LAST MINUTE REVISION CHECKLIST

## Theory to Remember:

- Definition of line of sight - write 5 times
- Definition of angle of elevation - write 5 times
- Definition of angle of depression - write 5 times
- Angle of elevation = Angle of depression (alternate angles)
- Standard angles table - write 20 times!
- All 6 trigonometric ratio formulas
- Which ratio to use when

## Quick Checks Before Writing Answer:

- Did I draw a clear diagram with labels?
- Did I identify the right triangle correctly?
- Did I mark all given information on diagram?
- Did I choose the correct trigonometric ratio?
- Did I use correct standard angle values?
- Did I add/subtract observer's height if mentioned?
- Did I rationalize the denominator if needed?
- Did I include units in final answer?
- Have I shown all steps clearly?
- Is final answer highlighted/boxed?

## Common Question Types:

- Height of tower/building given distance and angle
- Distance from tower given height and angle
- Ladder/rope length problems
- Shadow problems with two angles

- Flagstaff on building problems
- Angle of depression from height
- Two buildings with angles to each other
- Bridge/river width problems
- Observer at height problems
- Moving observer problems

**Before Exam:**

- Practice minimum 100 problems
- Solve last 5 years' board questions
- Time yourself - 3-10 min per question
- Memorize table - test yourself 10 times
- Practice drawing quick accurate diagrams
- Go through common mistakes list
- Review all NCERT examples
- Practice word problems (they're tricky!)
- Keep  $\sqrt{2}$  and  $\sqrt{3}$  values handy
- Practice rationalization



# EXPERT TIPS FOR SCORING FULL MARKS

## How to Score 100% in Heights and Distances:

### 1. Master diagram drawing (5 minutes practice daily):

- Draw neat, labeled diagrams
- Use ruler for straight lines
- Mark right angles clearly with square symbol
- Label all points (A, B, C, etc.)
- Mark given angle and measurements

### 2. Table memorization is NON-NEGOTIABLE:

- Write the table 50 times
- Test yourself without looking
- Focus on tan and cot especially
- Remember:  $\tan 30^\circ = 1/\sqrt{3}$ ,  $\tan 60^\circ = \sqrt{3}$  (not vice versa!)

### 3. Ratio selection strategy:

- Height + Distance → Always try tan or cot first
- Hypotenuse involved → Use sin or cos
- Write "Let" statements clearly
- Show which side is perpendicular, base, hypotenuse

### 4. Word problem approach:

- Read question THREE times
- Underline key information
- Draw diagram BEFORE starting solution
- Mark what's given and what's to find

### 5. Calculation accuracy:

- Keep  $\sqrt{3} = 1.732$ ,  $\sqrt{2} = 1.414$  handy

- Show rationalization steps
- Simplify radicals ( $\sqrt{12} = 2\sqrt{3}$ )
- Don't round off in between - only at end

**6. 6. Angle of depression mastery:**

- ALWAYS use alternate angle property
- Draw horizontal line through observer's eyes
- Mark alternate angles clearly
- Then proceed with normal trigonometry

**7. 7. Two-equation problems:**

- Form both equations clearly
- Label them (1) and (2)
- Show substitution steps
- Solve systematically

**8. 8. Observer's height - NEVER FORGET:**

- If problem mentions person/observer height - it's a TRAP!
- You MUST add this to calculated height
- Draw eye level line on diagram
- Calculate from eye level, then add observer height

**9. 9. Units and final answer:**

- ALWAYS include units (m, km, etc.)
- Box or underline final answer
- Write "Answer:" before final answer
- Check if approximation asked (use  $\sqrt{3} = 1.732$ )

**10. 10. Time management:**

- 2 marks question: 3-4 minutes max
- 3 marks question: 5-6 minutes max
- 5 marks question: 8-10 minutes max
- Practice with timer!

## BOARD EXAM PATTERN ANALYSIS

### Weightage and Distribution (Based on Recent Papers):

Question Type	Marks	Expected Questions	Total Marks
Very Short Answer	1-2	1	1-2
Short Answer	3	1	3
Long Answer	5	1	5
<b>Total from this chapter</b>			<b>8-10 marks</b>

### Most Frequently Asked Topics in Board Exams:

1. **Shadow problems (Two angles)** - 35% probability
2. **Angle of depression from height** - 30% probability
3. **Two buildings/objects** - 25% probability
4. **Basic height-distance** - 20% probability
5. **Moving observer** - 15% probability
6. **Ladder/rope problems** - 10% probability

**Pro Tip:** Practice shadow problems and angle of depression problems the most!



## PREVIOUS YEARS' BOARD QUESTIONS

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### Board Question 1 (CBSE 2023) - 3 Marks

**Question:** A 1.5 m tall boy is standing at some distance from a 30 m tall building. The angle of elevation from his eyes to the top of the building increases from  $30^\circ$  to  $60^\circ$  as he walks towards the building. Find the distance he walked towards the building. (Use  $\sqrt{3} = 1.73$ )

#### Marking Scheme:

- Diagram - 0.5 marks
- Two equations formed - 1 mark
- Solving - 1 mark
- Final answer - 0.5 marks

### Board Question 2 (CBSE 2022) - 5 Marks

**Question:** From a point on the ground, the angles of elevation of the bottom and top of a transmission tower fixed at the top of a 20 m high building are  $45^\circ$  and  $60^\circ$  respectively. Find the height of the tower. (Use  $\sqrt{3} = 1.73$ )

#### Marking Scheme:

- Diagram - 1 mark
- Finding building + tower distance ( $\tan 60^\circ$ ) - 1.5 marks
- Finding building distance ( $\tan 45^\circ$ ) - 1.5 marks
- Finding tower height - 0.5 marks
- Final answer - 0.5 marks

### Board Question 3 (CBSE 2020) - 3 Marks

**Question:** As observed from the top of a 75 m high lighthouse from the sea-level, the angles of depression of two ships are  $30^\circ$  and  $45^\circ$ . If one ship is exactly behind the other on the same side of the lighthouse, find the distance between the two ships. (Use  $\sqrt{3} = 1.732$ )

#### Marking Scheme:

- Diagram showing angles of depression - 0.5 marks
- Finding first distance ( $\tan 45^\circ$ ) - 1 mark
- Finding second distance ( $\tan 30^\circ$ ) - 1 mark
- Finding difference and answer - 0.5 marks

## GOLDEN TIPS FROM TOPPERS

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### Advice from 100% Scorers:

- **Topper 1 (Ananya, 100/100):** "I made flashcards for each problem type. Every day I practiced 10 problems - 5 old ones and 5 new ones. The key is REPETITION!"
- **Topper 2 (Raj, 100/100):** "I always drew diagrams first, even for simple problems. It helped me visualize and never miss observer's height."
- **Topper 3 (Priya, 99/100):** "I wrote the standard angles table every single day for 60 days. Now it's in my permanent memory!"
- **Topper 4 (Arjun, 100/100):** "For angle of depression problems, I ALWAYS used alternate angles. Never tried to solve directly. This one trick saved me so many times!"
- **Topper 5 (Sneha, 98/100):** "I maintained an error log. Every mistake I made went into a notebook. Before exam, I revised only my mistakes. Lost just 2 marks!"



# 30-DAY PREPARATION PLAN

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## Week 1: Foundation Building

- **Day 1-2:** Review trigonometric ratios and standard angles
- **Day 3-4:** Learn definitions (line of sight, angles of elevation/depression)
- **Day 5-6:** Study all NCERT examples thoroughly
- **Day 7:** Practice basic problems (15-20 problems)

## Week 2: Problem Solving

- **Day 8-9:** Solve NCERT Exercise 9.1 - Questions 1-5
- **Day 10-11:** Solve NCERT Exercise 9.1 - Questions 6-10
- **Day 12-13:** Solve NCERT Exercise 9.1 - Questions 11-15
- **Day 14:** Revise all NCERT solutions

## Week 3: Advanced Practice

- **Day 15-16:** Solve RD Sharma/RS Aggarwal problems
- **Day 17-18:** Previous years' board questions (2019-2024)
- **Day 19-20:** Sample papers (Chapter 9 only)
- **Day 21:** Mock test under exam conditions

## Week 4: Revision and Mastery

- **Day 22-23:** Revise all formulas and concepts
- **Day 24-25:** Practice difficult problems
- **Day 26-27:** Speed practice (20 problems in 2 hours)
- **Day 28-29:** Final revision, error log review
- **Day 30:** Light revision, confidence building

## RAPID FIRE PRACTICE (10 Minutes Daily)

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### Quick Recall Questions (Answer within 30 seconds each):

1. What is line of sight? (30 sec)
2. Define angle of elevation. (30 sec)
3. Define angle of depression. (30 sec)
4. Value of  $\tan 60^\circ$ ? (10 sec)
5. Value of  $\tan 30^\circ$ ? (10 sec)
6. Value of  $\sin 45^\circ$ ? (10 sec)
7. If distance = 10 m, angle =  $45^\circ$ , find height. (1 min)
8. Angle of elevation from ground = ? Angle of depression from height (15 sec)
9. Which ratio to use for height-distance problems? (15 sec)
10. Which ratio to use for ladder problems? (15 sec)



## SUMMARY OF KEY POINTS

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### Chapter Summary:


- ✓ **Line of sight:** Line from observer's eye to object
- ✓ **Angle of elevation:** Angle when looking UP (above horizontal)
- ✓ **Angle of depression:** Angle when looking DOWN (below horizontal)
- ✓ **Key property:** Angle of elevation = Angle of depression (alternate angles)
- ✓ **Most used ratio:**  $\tan \theta = \text{Height/Distance}$
- ✓ **Always remember:** Add observer's height if mentioned
- ✓ **Standard angles:** Must be memorized perfectly
- ✓ **Diagram is KEY:** Draw before solving

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