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CHAPTER NOTES

Some Applications of Trigonometry Class 10 Notes | CBSE Maths Chapter 9

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Hi, I am **Ira**. I teach this syllabus all day, so **Some Applications of 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 Some Applications of Trigonometry simply

What can the board exam ask?

Most important formulas

Quiz me on this chapter

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Some Applications of Trigonometry Class 10 Notes | CBSE Maths Chapter 9

Some Applications of Trigonometry is Chapter 9 of CBSE Class 10 Maths. It takes the trigonometric ratios from Chapter 8 and uses them to find heights and distances that cannot be measured with a tape: the height of a tower, the width of a river, the length of a kite string, or the gap between two ships seen from a lighthouse. The chapter defines the line of sight, the angle of elevation and the angle of depression, then solves problems with one or two right triangles.

For board exams this chapter is pure application. Every question turns a short story into a right triangle, picks the ratio that links the known side to the unknown side, and uses the values of sin, cos and tan at 30° , 45° and 60° . The seven worked examples and the fifteen questions of Exercise 9.1 give practice in each pattern: one triangle, two angles of elevation, and angles of depression.

Quick Answer - Some Applications

The **line of sight** joins the observer's eye to the object. The **angle of elevation** is the angle between the horizontal line and the line of sight when the point is above the horizontal line. The **angle of depression** is the angle between the horizontal line and the line of sight when it is below. To find a height or distance, choose the ratio that contains the known side. For example, if the **horizontal distance** is known, use $\sin \theta = \text{height} / \text{slant distance}$. The angle θ is measured from the eye. With two ratios, you can find the unknown side.



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All Key Formulas at a Glance

Idea	Formula or rule	Use it when
Height from horizontal distance	$h = d \tan \theta$	Tower, building or pole seen from a point on level ground
Horizontal distance from height	$d = h / \tan \theta = h \cot \theta$	Distance of a ship, car or point from the foot of a tower
Height from slant length	$h = L \sin \theta$	Rope, ladder, slide or kite string making angle θ with the ground
Horizontal reach of a slant line	$d = L \cos \theta$	
Observer's height	Total height = d t	
Angle of depression	Angle of depress = angle of elevat ground point	
tan values	$\tan 30^\circ = 1/\sqrt{3}$, t = $\sqrt{3}$	
sin values	$\sin 30^\circ = 1/2$, sin $60^\circ = \sqrt{3}/2$	
Two angles, same height h	$d_1 = h \cot \alpha$, $d_2 =$ - d_1	



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Key Concepts

1. Line of Sight, Angle of Elevation and Angle of Depression

A student stands some distance from a minar and looks at its top. The line from the eye to the top of the minar is the **line of sight**: the line drawn from the eye of an observer to the point in the object viewed by the observer. Its angle with the horizontal through the eye gets one of two names.

- **Angle of elevation**: the angle formed by the line of sight with the horizontal when the point being viewed is **above** the horizontal level. This is the case when we **raise** our head to look at the object: the top of a tower, a kite, a bird, a balloon.
- **Angle of depression**: the angle formed by the line of sight with the horizontal when the point being viewed is **below** the horizontal level. This is the case when we **lower** our head to look at the point: a girl on a balcony looking at a flower pot on the stair of a temple, a man on a lighthouse looking at a ship.

Feature	Angle of
Position of the object	Above the observer
Head movement	Raise the head
Measured from	The horizontal

Both angles are measured from the horizontal

The link between the two angles. A man stands on the ground at an angle of depression θ . The line of sight and the line of sight PA is a transversal. So alternate angles, and they are equal: the angle of depression from A. NCERT uses this step in Example 6

How the angle changes with distance. For a fixed angle. Walking towards a building raises the angle. A lighthouse lowers the angle of depression

What you need to find a height without climbing. The student's eye and B the point on the minar. You need: (i) the distance DE of the student from the foot of the minar, (ii) the angle of elevation



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$\angle BAC$ of the top, and (iii) the height AE of the student. In the right triangle ABC , BC is opposite to $\angle A$ and AB is adjacent to it, so $\tan A = BC/AB$ gives BC . Since $BD = AE$, the height of the minar is $CD = BC + BD = BC + AE$.

2. Choosing the Right Trigonometric Ratio

Every problem reduces to one or two right triangles in which you know one side and one angle. **Choose the ratio that contains the side you know and the side you want.**

You know / you want	Use	Typical object
Height and horizontal distance	$\tan \theta = \text{opposite/adjacent}$ (or $\cot \theta$)	Tower and ground, pole and shadow, building and ship
Height and slant length	$\sin \theta = \text{opposite/hy}$	
Horizontal distance and slant length	$\cos \theta = \text{adjacent/hy}$	

Values you must know by heart.

Ratio	30°
$\sin \theta$	$1/2$
$\cos \theta$	$\sqrt{3}/2$
$\tan \theta$	$1/\sqrt{3}$
$\cot \theta$	$\sqrt{3}$

Useful facts that come from the table.

- At 45° , $\tan 45^\circ = 1$, so the height equals distance: height = distance.
- For the same height h , the distance at 30° is three times the 60° distance,



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- If a pole's shadow is as long as the pole, $\tan \theta = 1$ and the Sun's altitude is 45° .

Keep surds exact. Write the answer as $15\sqrt{3}$ m or $10(\sqrt{3} - 1)$ m first. Convert to a decimal only at the last step, and only when the question says "take $\sqrt{3} = 1.73$ " or "1.732". Rationalise when a surd is in the denominator: $60/\sqrt{3} = 60\sqrt{3}/3 = 20\sqrt{3}$.

3. Heights and Distances with One Right Triangle

The simplest problems need one right triangle and four steps.

1. Sketch: the object vertical, the ground horizontal, the line of sight (or rope, ladder, string) slanting.
2. Mark the right angle at the foot of the object and the given angle at the correct vertex.
3. Pick the ratio that links the known side and the unknown side, and solve.
4. Add or subtract extra lengths, such as the height of the observer.

NCERT Example 1 (tower). A tower stands 15 m from the foot of the tower, the angle of elevation of the top of the tower from the point, with the triangle right-angled at the foot of the tower.

NCERT Example 2 (electrician and ladder)

point B that is 1.3 m below the top, so BD = 3.7 m. BD is horizontal. The ladder is the hypotenuse of a right triangle ABC. $\sin 60^\circ = \frac{BD}{BC} = \frac{3.7}{BC}$. So $BC = \frac{3.7}{\sin 60^\circ} = \frac{3.7}{1/\sqrt{3}} = 3.7 \times \sqrt{3} = 6.4$ m. The ladder is 6.4 m long. The distance from the pole to the base of the ladder is $DC = \sqrt{BC^2 - BD^2} = \sqrt{6.4^2 - 3.7^2} = \sqrt{28.49} \approx 5.34$ m. The ladder is about 5.34 m from the pole.

NCERT Example 3 (observer's height). A person of height 1.5 m is standing on a horizontal plane and the angle of elevation of the top from the observer's eye and E the point on AB level is 30° . Height of chimney = AE + BE = 28.5 m.

The observer's height rule. When the angle is measured from the ground, find the part above eye level with the triangle. If the angle is from the eyes, subtract a first. The observer's eyes are 1.5 m, so the triangle uses $30 - 1.5 = 28.5$ m.

Broken tree. The standing part is the vertical height. The horizontal distance from the base of the tree to the point where the tree broke is the base. The original height of the tree is the hypotenuse.



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4. Two Angles of Elevation of the Same Object

Many questions give two angles of the same object. This happens in four common ways:

- An observer walks towards or away from a building, and the angle of elevation changes.
- A tower's shadow is longer at one altitude of the Sun than at another.
- One point sees two things on the same vertical line: a building and a flagstaff on it, a pedestal and a statue on it.
- A point lies between two objects, such as two poles on opposite sides of a road.

Method. Call the height h and a distance x . Write one $\tan$ equation per right triangle, then substitute one into the other.

NCERT Example 4 (building and flagstaff). From a point P , the angle of elevation of the top B of a 10 m building AB is 30° , and the angle of elevation of the top C of a flagstaff BC is 45° . In right $\triangle PAB$, $\tan 30^\circ = AB/AP$, so $1/\sqrt{3} = 10/AP$, so $AP = 10\sqrt{3}$ m. In right $\triangle PAC$, $\tan 45^\circ = AC/AP$, so $1 = (10 + x)/AP$, so $AP = 10 + x$ m. In right $\triangle PAB$, $10\sqrt{3} - 10 = 10(\sqrt{3} - 1) = 7.32$ m.

The Sun's altitude. The altitude of the Sun is θ . The height of the building is h , the angle of elevation of its top from a point P is α . The length of the shadow is $h \cot \theta$. The lower the altitude, the longer the shadow.

NCERT Example 5 (two shadows). The shadow of a building is 40 m long when the altitude of the Sun is 30° than when it is 60° . Let the height of the building be h m. In right $\triangle ABC$, the longer shadow $DB = (x + 40)$ m. In $\triangle ABC$, $\tan 30^\circ = h/(x + 40)$, so $1/\sqrt{3} = h/(x + 40)$... (2). Putting $x = 20$. Then $h = 20\sqrt{3}$ m.

Shortcut for 30° and 60° . For the same height, the difference in the lengths of the shadows is $2h/\sqrt{3}$. In Example 5 the gap is 40, so $2h/\sqrt{3} = 40$, so $h = 20\sqrt{3}$ m. Use it to check; show the full working in the margin.

5. Problems Using Angles of Depression

Angles of depression are measured at the eye. The angle of depression of an object is the angle between the horizontal line and the line of sight. The first move every time is to transfer the angle of depression to the angle of elevation.



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an angle of elevation (alternate angles). After that the problem is solved exactly like an elevation problem.

NCERT Example 6 (two buildings). From the top P of a multi-storeyed building PC, the angles of depression of the top B and the bottom A of an 8 m building AB are 30° and 45° . Draw BD horizontal from B to meet PC at D. Then $\angle PBD = 30^\circ$ and $\angle PAC = 45^\circ$ (alternate angles). In right $\triangle PBD$, $PD/BD = \tan 30^\circ = 1/\sqrt{3}$, so $BD = PD\sqrt{3}$. In right $\triangle PAC$, $PC/AC = \tan 45^\circ = 1$, so $PC = AC$. Also $PC = PD + DC$ with $DC = AB = 8$ m, and $AC = BD$. So $PD + 8 = PD\sqrt{3}$, giving $PD = 8/(\sqrt{3} - 1) = 8(\sqrt{3} + 1)/2 = 4(\sqrt{3} + 1)$ m. The height $PC = 4(\sqrt{3} + 1) + 8 = 4(3 + \sqrt{3})$ m, and the distance between the buildings is also $4(3 + \sqrt{3})$ m.

NCERT Example 7 (river and bridge). From a point P on a bridge 3 m above the banks, the angles of depression of the banks on opposite sides are 30° and 45° . Let A and B be the banks and D the point on AB directly below P, so $PD = 3$ m. In right $\triangle APD$, $\angle A = 30^\circ$ and $\tan 30^\circ = PD/AD$, so $AD = 3\sqrt{3}$ m. In right $\triangle PBD$, $\angle B = 45^\circ$, so $BD = PD = 3$ m. Width $AB = AD + DB = 3\sqrt{3} + 3 = 3(1 + \sqrt{3})$ m.

Same side or opposite sides.

Arrangement	What to do
Both points on the same side of the tower (one behind the other)	Subtract the distance from the tower to the other point from the distance to the first point
Points on opposite sides of the tower or bridge	Add the distance from the tower to the first point to the distance to the second point

Elevation and depression from one point. From the top of a taller tower (elevation) and its foot (depression) to the top of a shorter tower. It splits the tower into a lower part and an upper part. Exercise 9.1 Q12

6. A Complete Method, Including 1

1. **Sketch** and mark every given length and angle.
2. **Find the right triangles.** Name them with letters. Mark the right angle.



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3. **Move depression angles** to the ground point as equal elevation angles.
4. **Adjust for eye height** if the angle is measured from the eyes.
5. **Write one equation per triangle** using the ratio that contains the known and unknown sides.
6. **Solve**, keeping surds exact. Rationalise the denominator.
7. **State the answer with units**, and in decimals if the question gives a value for $\sqrt{3}$.

Moving objects. Some problems add speed and time. A car approaching a tower at a uniform speed changes its angle of depression. A balloon moving horizontally changes its angle of elevation. Find each position with a tan equation, subtract to get the distance travelled, then use speed = distance/time.

For the car in Exercise 9.1 Q15, with tower height h , the distance at 30° is $h/\sqrt{3}$ and at 60° is $h/\sqrt{3}$. The car covers $h/\sqrt{3} - h/\sqrt{3} = 2h/\sqrt{3}$ in 6 seconds and still has $h/\sqrt{3}$ to go. The remaining distance is half the distance already covered, so at the same speed it takes half the time: 3 seconds. The height h cancels out, so the answer does not depend on how tall the tower is.

Sense check. At 60° the height exceeds the distance, so the distance is always longer than the height it reaches.



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Formula and Theorem Sheet

Situation	Relation	Remember
Height h , horizontal distance d , elevation θ	$\tan \theta = h/d$, so $h = d \tan \theta$ and $d = h \cot \theta$	The most used relation in the chapter
Slant length L making θ with the ground	$h = L \sin \theta$, $d = L \cos \theta$	Rope, ladder, slide, kite string
Observer of height a , angle from the eyes	Object height = $d \tan \theta + a$	Subtract a first if the object height is given
Angle of depression θ from height h	Ground distance = $h \cot \theta$	Equal to the angle of elevation at the ground point (alternate angles)
Same height, angles 30° and 60°	Distance gap = $2h$	
Same height, angles 30° and 45°	Distance = $h(\sqrt{3} - 1)$	
Object on a base (flagstaff, statue, tower on a building)	Base height total = $d \tan \theta$ difference = $d \tan \theta - a$	
Shadow of height h , Sun's altitude θ	Shadow = $h \cot \theta$	
Rationalising	$1/(\sqrt{3} - 1) \times (\sqrt{3} + 1)/(\sqrt{3} + 1)$ $1/(\sqrt{3} + 1) \times (\sqrt{3} - 1)/(\sqrt{3} - 1)$	



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Important Definitions

- Line of sight:** the line drawn from the eye of the observer.

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- **Angle of elevation:** the angle formed by the line of sight with the horizontal when the point being viewed is above the horizontal level, that is, when we raise our head to look at the object.
- **Angle of depression:** the angle formed by the line of sight with the horizontal when the point being viewed is below the horizontal level, that is, when we lower our head to look at the point being viewed.
- **Horizontal level:** the level line through the observer's eye, parallel to the level ground. Both angles are measured from it.
- **Altitude of the Sun:** the angle of elevation of the Sun. It equals the angle of elevation of the top of a vertical object from the tip of its shadow.
- **Heights and distances:** the use of trigonometric ratios to find the height or length of an object, or the distance between two distant objects, without measuring them directly.

Solved Examples (NCERT)

Example 1: The broken tree (NCERT)

A tree breaks due to storm and the broken part bends so that the top of the tree touches the ground making an angle 30° with it. The distance from the foot of the tree to the point where the top touches the ground is 8 m. Find the height of the tree.

Solution: Let B be the foot of the tree, A the point where the top touches the ground. AB is the standing part, AC the broken part.

$$\tan 30^\circ = \frac{AB}{BC} \Rightarrow \frac{1}{\sqrt{3}} = \frac{AB}{8} \Rightarrow AB = \frac{8}{\sqrt{3}}$$

$$\cos 30^\circ = \frac{BC}{AC} \Rightarrow \frac{\sqrt{3}}{2} = \frac{8}{AC} \Rightarrow AC = \frac{16}{\sqrt{3}}$$

$$\text{Height of tree} = AB + AC = \frac{8}{\sqrt{3}} + \frac{16}{\sqrt{3}} = \frac{24}{\sqrt{3}} = 8\sqrt{3} \text{ m}$$

The tree was $8\sqrt{3} \text{ m} \approx 13.86 \text{ m}$ high.

Example 2: Two slides in a park (NCERT)

A contractor plans to install two slides for the age of 5 years, she prefers to have a slide for the younger children at an angle of 30° to the ground, whereas for the older children at an angle of 60° to the ground.



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height of 3 m, and inclined at an angle of 60° to the ground. What should be the length of the slide in each case?

Solution: The slide is the hypotenuse and its height is opposite the angle, so use sin.

Small slide: $\sin 30^\circ = 1.5/L_1 \Rightarrow 1/2 = 1.5/L_1 \Rightarrow L_1 = 3 \text{ m}$.

Steep slide: $\sin 60^\circ = 3/L_2 \Rightarrow \sqrt{3}/2 = 3/L_2 \Rightarrow L_2 = 6/\sqrt{3} = 2\sqrt{3} \text{ m}$.

The slides should be 3 m and $2\sqrt{3} \text{ m}$ ($\approx 3.46 \text{ m}$) long.

Example 3: The boy walking towards a building (NCERT Exercise 9.1, Q6)

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° to 60° as he walks towards the building. Find the distance he walked towards the building.

Solution: The angles are measured from his eyes, so the height is 28.5 m. Let the horizontal distances from the building be d_1 and d_2 for 30° and 60° respectively.

$$\tan 30^\circ = 28.5/d_1 \Rightarrow d_1 = 28.5\sqrt{3} \text{ m}.$$

$$\tan 60^\circ = 28.5/d_2 \Rightarrow d_2 = 28.5/\sqrt{3} \text{ m}.$$

$$\text{Distance walked} = d_1 - d_2 = 28.5(\sqrt{3} - 1/\sqrt{3}) = 19\sqrt{3} \text{ m} \approx 32.91 \text{ m}.$$

He walked $19\sqrt{3} \text{ m} \approx 32.91 \text{ m}$.

Example 4: Transmission tower on a hill

From a point on the ground, the angles of elevation of the top of a transmission tower fixed at the top of a 20 m high building are 45° and 60° . Find the height of the tower.

Solution: Let P be the point, B the foot of the building (and the foot of the tower) and D the top of the tower. $BC = 20 \text{ m}$.

$$\text{In } \triangle PBC: \tan 45^\circ = BC/PB \Rightarrow 1 = 20/PB \Rightarrow PB = 20 \text{ m}.$$

$$\text{In } \triangle PBD: \tan 60^\circ = BD/PB \Rightarrow \sqrt{3} = (20 + h)/20 \Rightarrow h = 20(\sqrt{3} - 1) \text{ m}.$$



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The tower is $20(\sqrt{3} - 1)$ m ≈ 14.64 m high.

Example 5: Statue on a pedestal (NCERT Exercise 9.1, Q8)

A statue, 1.6 m tall, stands on the top of a pedestal. From a point on the ground, the angle of elevation of the top of the statue is 60° and from the same point the angle of elevation of the top of the pedestal is 45° . Find the height of the pedestal.

Solution: Let the pedestal be h m high and the point be d m from its foot.

Top of pedestal: $\tan 45^\circ = h/d \Rightarrow d = h$.

Top of statue: $\tan 60^\circ = (h + 1.6)/d \Rightarrow \sqrt{3}h = h + 1.6 \Rightarrow h(\sqrt{3} - 1) = 1.6$.

$h = 1.6/(\sqrt{3} - 1) = 1.6(\sqrt{3} + 1)/(3 - 1) = 0.8(\sqrt{3} + 1)$.

The pedestal is $0.8(\sqrt{3} + 1)$ m ≈ 2.19 m high.

Example 6: Building and tower (NCERT Exercise 9.1, Q9)

The angle of elevation of the top of a building from the foot of a tower is 30° and the angle of elevation of the top of the tower from the top of the building is 60° . Find the height of the building.

Solution: Let the distance between the feet of the building and the tower be d m and the height of the building be h m high.

From the foot of the building: $\tan 60^\circ = 50/d \Rightarrow d = 50/\sqrt{3}$.

From the foot of the tower: $\tan 30^\circ = h/d \Rightarrow h = d/\sqrt{3} = 50/3$.

The building is $50/3$ m $= 16 \frac{2}{3}$ m ≈ 16.67 m high.

Example 7: Two poles across a road (NCERT Exercise 9.1, Q10)

Two poles of equal heights are standing on opposite sides of a road which is 80 m wide. From a point between them on the road, the angles of elevation of the tops of the poles are 60° and 30° , respectively. Find the height of the poles and the distance of the point from the poles.

Solution: Let each pole be h m high and the point be x m from one pole and $(80 - x)$ m from the other pole.



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$$\tan 60^\circ = h/x \Rightarrow h = \sqrt{3} x \dots(1)$$

$$\tan 30^\circ = h/(80 - x) \Rightarrow h = (80 - x)/\sqrt{3} \dots(2)$$

From (1) and (2): $\sqrt{3} x = (80 - x)/\sqrt{3} \Rightarrow 3x = 80 - x \Rightarrow x = 20$. Then $h = 20\sqrt{3}$.

Each pole is $20\sqrt{3} \text{ m} \approx 34.64 \text{ m}$ high. The point is 20 m from one pole and 60 m from the other.

Example 8: TV tower across a canal (NCERT Exercise 9.1, Q11)

A TV tower stands vertically on a bank of a canal. From a point on the other bank directly opposite the tower, the angle of elevation of the top of the tower is 60° . From another point 20 m away from this point on the line joining this point to the foot of the tower, the angle of elevation of the top of the tower is 30° . Find the height of the tower and the width of the canal.

Solution: Let the tower be $h \text{ m}$ high and the canal $x \text{ m}$ wide. The second point is 20 m further away, at $(x + 20) \text{ m}$.

$$\tan 60^\circ = h/x \Rightarrow h = \sqrt{3} x \dots(1)$$

$$\tan 30^\circ = h/(x + 20) \Rightarrow h = (x + 20)/\sqrt{3} \dots(2)$$

From (1) and (2): $3x = x + 20 \Rightarrow x = 10$. The

The tower is $10\sqrt{3} \text{ m} \approx 17.32 \text{ m}$ high and the canal is 10 m wide.

Example 9: Cable tower from a building

From the top of a 7 m high building, the angle of depression of the foot of a cable tower is 45° . From the foot of the building, the angle of depression of its foot is 45° . Find the height of the cable tower.

Solution: Let A be the top of the building, B be the foot of the building, C be the top of the cable tower, and D be the foot of the cable tower. AE horizontal from A to meet CD at E. The

Depression of C is 45° , so $\angle ACB = 45^\circ$ (alt angles). In $\triangle AED$, $\angle AED = 90^\circ$, $\angle ADE = 45^\circ$, and $AE = 7 \text{ m}$.

In $\triangle AED$: $\tan 60^\circ = DE/AE \Rightarrow DE = 7\sqrt{3} \text{ m}$.

Height of tower = $DE + EC = 7\sqrt{3} + 7 = 7(\sqrt{3} + 1) \text{ m}$.



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The tower is $7(\sqrt{3} + 1)$ m ≈ 19.12 m high.

Example 10: Two ships from a lighthouse (NCERT Exercise 9.1, Q13)

As observed from the top of a 75 m high lighthouse from the sea-level, the angles of depression of two ships are 30° and 45° . If one ship is exactly behind the other on the same side of the lighthouse, find the distance between the two ships.

Solution: Each angle of depression equals the angle of elevation of the top of the lighthouse from that ship. The ship at 45° is nearer.

Near ship: $\tan 45^\circ = 75/d_1 \Rightarrow d_1 = 75$ m.

Far ship: $\tan 30^\circ = 75/d_2 \Rightarrow d_2 = 75\sqrt{3}$ m.

Both ships are on the same side, so subtract: $d_2 - d_1 = 75\sqrt{3} - 75 = 75(\sqrt{3} - 1)$.

The ships are $75(\sqrt{3} - 1)$ m ≈ 54.9 m apart.

Example 11: The balloon (NCERT Exercise 9.1, Q14)

A 1.2 m tall girl spots a balloon moving with a speed of 29 m/s from the ground. The angle of elevation of the balloon from her eyes is initially 60° . After some time, the angle of elevation reduces to 30° . Find the distance travelled by the balloon during the interval.

Solution: The angles are from her eyes, so we add 1.2 m to the height of the tower in both positions.

First position: $\tan 60^\circ = 87/d_1 \Rightarrow d_1 = 87/\sqrt{3}$

Second position: $\tan 30^\circ = 87/d_2 \Rightarrow d_2 = 87\sqrt{3}$

Distance travelled = $d_2 - d_1 = 87\sqrt{3} - 29\sqrt{3}$

The balloon travelled $58\sqrt{3}$ m ≈ 100.46 m

Example 12: The car on the highway (NCERT Exercise 9.1, Q15)

A straight highway leads to the foot of a tower. A car is seen from the top of the tower at an angle of depression of 30° , which



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speed. Six seconds later, the angle of depression of the car is found to be 60° . Find the time taken by the car to reach the foot of the tower from this point.

Solution: Let the tower be h m high. The depression angles become elevation angles at the car.

At 30° : distance = $h/\tan 30^\circ = h\sqrt{3}$. At 60° : distance = $h/\tan 60^\circ = h/\sqrt{3}$.

Distance covered in 6 s = $h\sqrt{3} - h/\sqrt{3} = (3h - h)/\sqrt{3} = 2h/\sqrt{3}$.

Speed = $(2h/\sqrt{3}) \div 6 = h/(3\sqrt{3})$ m/s.

Time for the remaining $h/\sqrt{3} = (h/\sqrt{3}) \div (h/(3\sqrt{3})) = 3$ s.

The car takes 3 seconds more to reach the foot of the tower.

Competency-Based Questions

1. Case-based: The lighthouse keeper

A lighthouse stands on a rock at the edge of the sea. A lighthouse keeper watches a boat sailing straight towards the lighthouse. The angle of elevation of the boat from the lamp is 30° . Later it is 60° .

(a) Name the angle equal to the angle of elevation of the boat from the lamp from the boat, because the two are alternate angles.

(b) Find the first distance of the boat from the lighthouse.

(c) How far did the boat sail between the two observations?
Distance = $60\sqrt{3} - 20\sqrt{3} = 40\sqrt{3}$ m ≈ 69.2 m.

2. Case-based: A ramp to a stage

A school builds a straight ramp from the ground to a stage. The ramp makes an angle of 30° with the ground.



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(a) Which ratio links the ramp length with the height? $\sin 30^\circ$, since the ramp is the hypotenuse and the height is opposite the angle.

(b) Find the length of the ramp. $\sin 30^\circ = 0.9/L \Rightarrow L = 1.8 \text{ m}$.

(c) How far from the stage does the ramp start? $d = L \cos 30^\circ = 1.8 \times \sqrt{3}/2 = 0.9\sqrt{3} \approx 1.56 \text{ m}$ (taking $\sqrt{3} = 1.73$).

3. Source-based: What you need to measure a minar

NCERT says that to find the height CD of a minar you need the distance DE of the student from its foot, the angle of elevation $\angle BAC$ of the top, and the height AE of the student. $BD = AE$, and $\tan A$ or $\cot A$ gives BC.

(a) Why is $\tan A$ chosen and not $\sin A$? In $\triangle ABC$ the known side AB (equal to DE) and the wanted side BC are the two sides at the right angle. $\tan A = BC/AB$ contains both. $\sin A$ would need the hypotenuse AC, which is unknown.

(b) If $DE = 40 \text{ m}$, $\angle BAC = 45^\circ$ and $AE = 1.6 \text{ m}$. $CD = BC + BD = 40 + 1.6 = 41.6 \text{ m}$.

4. Assertion-Reason

Assertion (A): The angle of depression of the top of the cliff from the bottom of the cliff is equal to the angle of elevation of the top of the cliff from the bottom of the cliff.

Reason (R): The horizontal through the observer and the horizontal through the object are parallel and the angles are alternate angles.

Choose: (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 statements are true, and the angles are equal.

5. Assertion-Reason

Assertion (A): If the length of the shadow of a tower is equal to the height of the tower, then the altitude is 45° .

Reason (R): $\sin 45^\circ = \cos 45^\circ$.

Choose: (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.



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Answer: (b). A is true because $\tan \theta = \text{height/shadow} = 1$ gives $\theta = 45^\circ$. R is also true, since both equal $1/\sqrt{2}$. R does not explain A; the explanation uses $\tan \theta = 1$.

6. Assertion-Reason

Assertion (A): As an observer walks away from a tower, the angle of elevation of its top increases.

Reason (R): For a fixed height h , the distance $d = h \cot \theta$, and $\cot \theta$ decreases as θ increases.

Choose: (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). A is false: walking away increases d , so $\cot \theta$ must increase, which means θ decreases. R is true.

7. Error analysis: The missing eye height

A student solves: "A 1.6 m tall man stands ... the tree from his eyes is 45° . Height of the ... it.

Answer: The angle is measured from his eye ... above eye level, 20 m. The man's height m

8. Competency MCQ: The ladder

A ladder 10 m long leans against a vertical ... high up the wall does it reach?

(a) 5 m (b) $5\sqrt{3}$ m (c) $10\sqrt{3}$ m (d) $10/\sqrt{3}$ m

Answer: (b). Height = $10 \sin 60^\circ = 10 \times \sqrt{3}/2$... the wall, $10 \cos 60^\circ = 5$ m. The height (≈ 8 ... (c).



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Important Questions for Board Exams

1-Mark Questions

1. **Define the angle of depression.** It is the angle formed by the line of sight with the horizontal when the point being viewed is below the horizontal level, as when we lower our head to look at it.
2. **The angle of elevation of the top of a tower from a point on the ground, which is 30 m away from the foot of the tower, is 30° . Find the height of the tower.** (NCERT Exercise 9.1, Q4) $h = 30 \tan 30^\circ = 30/\sqrt{3} = 10\sqrt{3} \text{ m} \approx 17.32 \text{ m}$.
3. **A pole 6 m high casts a shadow $2\sqrt{3}$ m long. Find the Sun's altitude.** $\tan \theta = 6/(2\sqrt{3}) = \sqrt{3}$, so $\theta = 60^\circ$.
4. **If the height of a tower and the distance of a point from its foot are equal, find the angle of elevation of the top from that point.** $\tan \theta = 1$, so $\theta = 45^\circ$.

2-Mark Questions

1. **A ladder makes an angle of 60° with the ground. The length of the ladder is 2.5 m. Find the height of the ladder.** $\cos 60^\circ = 2.5/L \Rightarrow L = 5 \text{ m}$.
2. **From the top of a 50 m high cliff, the angle of depression of the boat from the foot of the cliff is 30° . Find the distance of the boat from the foot of the cliff.** $50 = 50\sqrt{3} \text{ m} \approx 86.6 \text{ m}$.
3. **The angles of elevation of the top of a tower from two points on the same side and in the same straight line with the foot of the tower are θ and $90^\circ - \theta$. The distance between the two points is 36 m. Find the height of the tower.** Let the angles be θ and $90^\circ - \theta$. $\tan \theta \times \cot \theta = h^2/36$, so $1 = h^2/36$ and $h = 6 \text{ m}$.



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3-Mark Questions

1. **A kite is flying at a height of 60 m above the ground. The string is tied to a point on the ground and makes an angle of 60° with the ground. Find the length of the string, assuming that there is no slack in the string.** (NCERT Exercise 9.1, Q5) $\sin 60^\circ = 60/L \Rightarrow L = 120/\sqrt{3} = 40\sqrt{3} \text{ m}$.
2. **The angle of elevation of the top of a tower from a point on the ground is 30° . From another point 20 m towards the tower, the angle becomes 60° . Find the height of the tower.** $h\sqrt{3} - h/\sqrt{3} = 20 \Rightarrow 2h/\sqrt{3} = 20 \Rightarrow h = 10\sqrt{3} \text{ m}$.

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3. **From the top of a 60 m high building, the angles of depression of the top and the bottom of a tower are 30° and 60° . Find the height of the tower.** From the bottom (60°): distance $d = 60/\tan 60^\circ = 20\sqrt{3}$ m. From the top (30°): the building rises above the tower's top by $d \tan 30^\circ = 20\sqrt{3} \times 1/\sqrt{3} = 20$ m. Tower = $60 - 20 = 40$ m.

5-Mark Questions

1. **The angles of depression of the top and the bottom of an 8 m tall building from the top of a multi-storeyed building are 30° and 45° , respectively. Find the height of the multi-storeyed building and the distance between the two buildings.** (NCERT Example 6) Let the multi-storeyed building be PC and the small building AB, and draw BD horizontal to meet PC at D. From 45° : PC = AC. From 30° : BD = PD $\sqrt{3}$. Since AC = BD and PC = PD + 8, PD + 8 = PD $\sqrt{3}$, so PD = $8/(\sqrt{3} - 1) = 4(\sqrt{3} + 1)$. Height PC = $4(\sqrt{3} + 1) + 8 = 4(3 + \sqrt{3})$ m ≈ 18.93 m. Distance AC = PC = $4(3 + \sqrt{3})$ m.
2. **A man on the deck of a ship is 10 m above the water level. He sees the top of a cliff at an angle of elevation of 45° and its base at an angle of depression of 30° . Find the distance of the cliff from the ship and the height of the cliff.** Top (45°): the part of the cliff above the water level is 10 m. Bottom (30°): the part of the cliff below the water level is $10\sqrt{3}$ m. Total height = $10 + 10\sqrt{3} = 10(\sqrt{3} + 1)$ m ≈ 27.32 m.



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Common Mistakes and Examples

- Measuring the angle from the vertical.** The angle of depression is measured from the horizontal. If a question gives an angle with the ground is 90° minus that angle.
- Placing the angle of depression at the wrong point.** The angle of depression is between the horizontal and the line of sight from the observer's eye. The angle of elevation is at the ground point.
- Forgetting the observer's height.** "From the top of a 60 m high building..." the eye height to the answer, or subtract it (Exercise 9.1).
- Using sin when tan is needed.** Height and distance are related by tan, sin only when the hypotenuse (rope, ladder) is given.
- Giving only the standing part of a broken pole.** In Exercise 9.1 Q2 it is $8/\sqrt{3}$ m, not just 8 m.
- Adding when you should subtract.** Two points on a river, or a point between two poles, add them. Two points on a cliff, subtract them.

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7. **Swapping the two angles.** The larger angle belongs to the nearer point. At 60° the observer is closer than at 30° .
8. **Using decimals too early.** Writing $1/\sqrt{3}$ as 0.577 in the first line causes rounding errors. Keep surds to the end and convert once, with the value the question gives.
9. **Leaving a surd in the denominator.** Write $40\sqrt{3}$, not $120/\sqrt{3}$. For $8/(\sqrt{3} - 1)$, multiply by $(\sqrt{3} + 1)/(\sqrt{3} + 1)$ to get $4(\sqrt{3} + 1)$.
10. **Skipping the figure.** A clear labelled sketch shows your method, even if the arithmetic slips. Name every point you use in an equation.
11. **Answering the wrong quantity.** Exercise 9.1 Q7 asks for the tower on the building, $20(\sqrt{3} - 1)$ m, not the total height $20\sqrt{3}$ m. Q15 asks for the time after the second sighting, 3 s, not the speed. Reread the last line of the question, and give units.

Quick Revision Points

- The line of sight is the line from the observer to the object.
- Angle of elevation: object above eye level.
- Angle of depression: object below eye level.
- Both angles are measured from the horizontal.
- Angle of depression from the top = angle of elevation (alternate angles).
- Height and horizontal distance: use $\tan$ for height, $\cos$ for distance.
- $\tan 30^\circ = 1/\sqrt{3}$, $\tan 45^\circ = 1$, $\tan 60^\circ = \sqrt{3}$.
- $\sin 30^\circ = 1/2$, $\sin 45^\circ = 1/\sqrt{2}$, $\sin 60^\circ = \sqrt{3}/2$.
- At 45° , height = horizontal distance.
- $h = d \tan \theta$ and $d = h \cot \theta$.
- Angle measured from the eyes: add the angles.
- For the same height, the 30° distance is twice the 60° distance.
- Two angles: write one equation per triangle.
- Same side: subtract distances. Opposite sides: add distances.
- Broken tree height = standing part + broken part.



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- Shadow length = $h \cot$ (Sun's altitude). Lower Sun, longer shadow.
- Object on a base: find the base and the total from the same point, then subtract.
- Moving objects: distance travelled = difference of the two distances, then speed = distance/time.
- Keep surds exact and rationalise: $1/(\sqrt{3} - 1) = (\sqrt{3} + 1)/2$.
- Answer checks: at 60° the height exceeds the distance; a slant length always exceeds the height.

Weightage in Board Exams

Some Applications of Trigonometry builds directly on Introduction to Trigonometry (Chapter 8) and uses its ratios and standard values throughout. Check the current CBSE course structure for the marks given to this part of the syllabus. This chapter supplies the application questions on heights and distances.

Question type	
MCQ and Assertion-Reason	Definitions of ele and its shadow; c
Short answers	One right triangle
Long answers	Two angles: mov base, two buildin
Case-based	A real setting suc that build from o

A good answer shows a labelled figure, th answer with units. Practise every NCERT e



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