

Mathematics

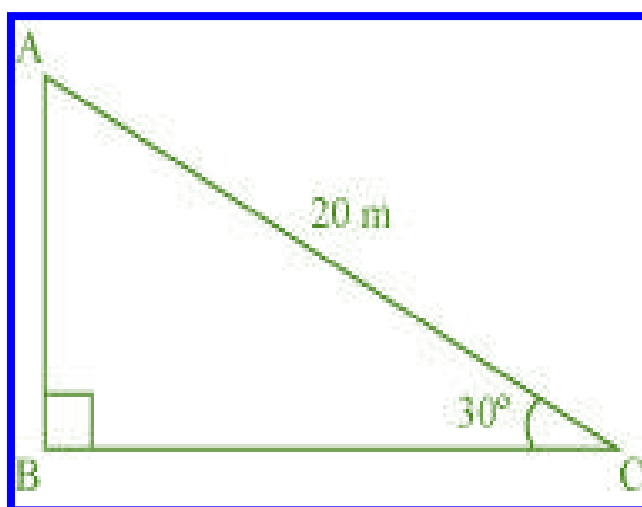
(Chapter – 9) (Some Applications of Trigonometry)

(Class – X)

Exercise 9.1

Question 1:

A circus artist is climbing a 20 m long rope, which is tightly stretched and tied from the top of a vertical pole to the ground. Find the height of the pole, if the angle made by the rope with the ground level is 30° .



Answer 1:

It can be observed from the figure that AB is the pole.

In $\triangle ABC$,

$$\frac{AB}{AC} = \sin 30^\circ$$

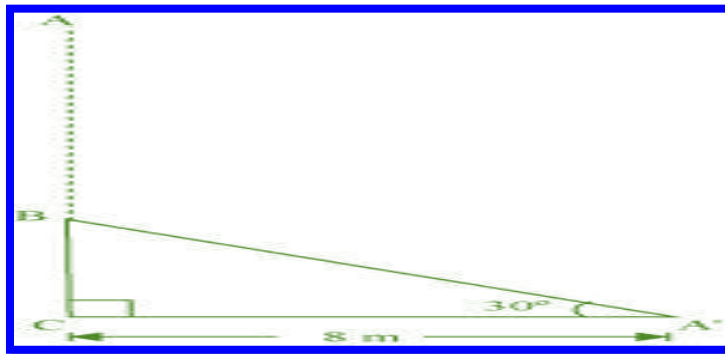
$$\frac{AB}{20} = \frac{1}{2}$$

$$AB = \frac{20}{2} = 10$$

Therefore, the height of the pole is 10 m.

Question 2:

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 between the foot of the tree to the point where the top touches the ground is 8 m. Find the height of the tree.

Answer 2:

Let AC was the original tree. Due to storm, it was broken into two parts. The broken part $A'B$ is making 30° with the ground.

$$\begin{aligned}\text{In } \triangle A'BC, \quad \frac{BC}{A'C} &= \tan 30^\circ \\ \frac{BC}{8} &= \frac{1}{\sqrt{3}} \\ BC &= \left(\frac{8}{\sqrt{3}} \right) \text{m} \\ \frac{A'C}{A'B} &= \cos 30^\circ \\ \frac{8}{A'B} &= \frac{\sqrt{3}}{2} \\ A'B &= \left(\frac{16}{\sqrt{3}} \right) \text{m}\end{aligned}$$

Height of the tree = $A'B + BC$

$$\begin{aligned}&= \left(\frac{16}{\sqrt{3}} + \frac{8}{\sqrt{3}} \right) \text{m} = \frac{24}{\sqrt{3}} \text{ m} \\ &= 8\sqrt{3} \text{ m}\end{aligned}$$

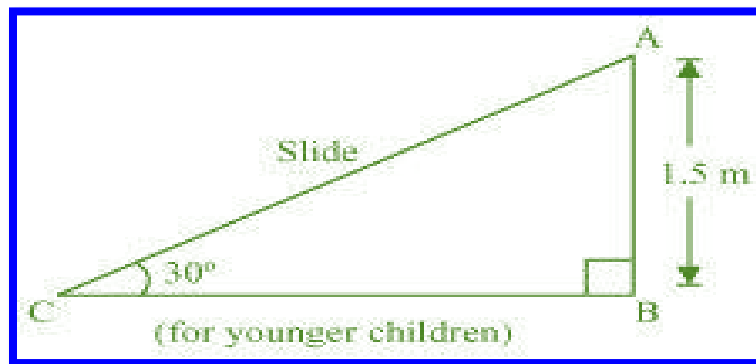
Hence, the height of the tree is $8\sqrt{3}$ m.

Question 3:

A contractor plans to install two slides for the children to play in a park. For the children below the age of 5 years, she prefers to have a slide whose top is at a height of 1.5 m, and is inclined at an angle of 30° to the ground, whereas for the elder children she wants to have a steep side at a 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?

Answer 3:

It can be observed that AC and PR are the slides for younger and elder children respectively.

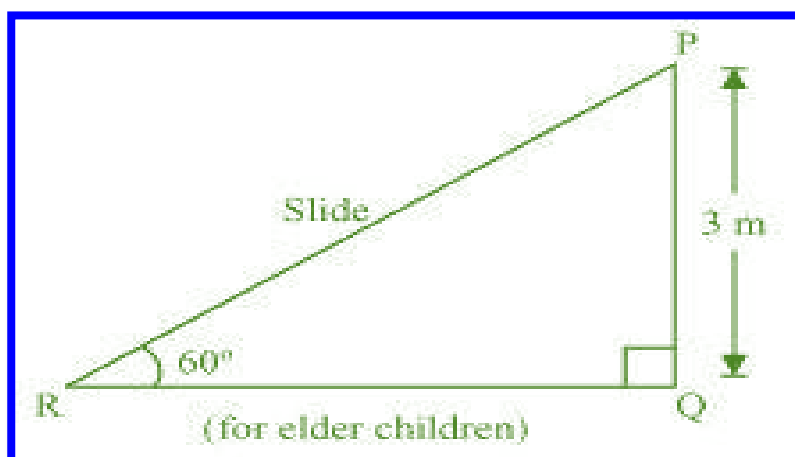


In $\triangle ABC$,

$$\frac{AB}{AC} = \sin 30^\circ$$

$$\frac{1.5}{AC} = \frac{1}{2}$$

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



In $\triangle PQR$,

$$\frac{PQ}{PR} = \sin 60$$

$$\frac{3}{PR} = \frac{\sqrt{3}}{2}$$

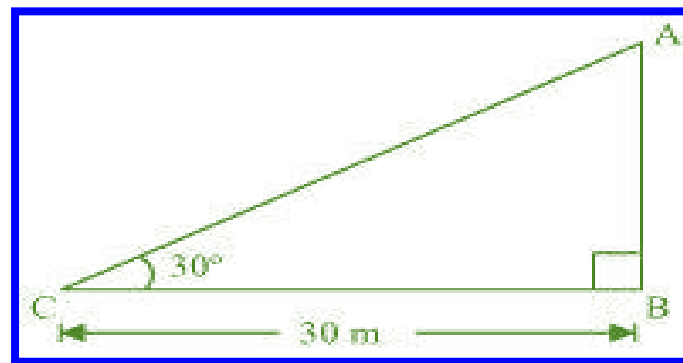
$$PR = \frac{6}{\sqrt{3}} = 2\sqrt{3} \text{ m}$$

Therefore, the lengths of these slides are 3 m and $2\sqrt{3}$ m.

Question 4:

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.

Answer 4:



Let AB be the tower and the angle of elevation from point C (on ground) is 30° .
In $\triangle ABC$,

$$\frac{AB}{BC} = \tan 30^\circ$$

$$\frac{AB}{30} = \frac{1}{\sqrt{3}}$$

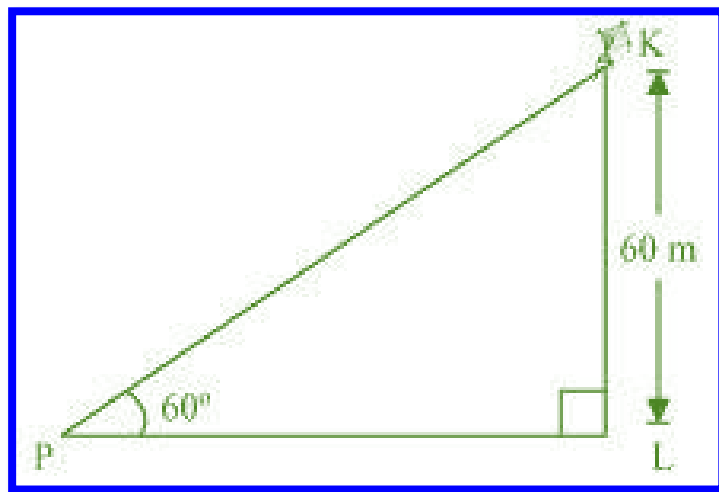
$$AB = \frac{30}{\sqrt{3}} = 10\sqrt{3} \text{ m}$$

Therefore, the height of the tower is $10\sqrt{3}$ m.

Question 5:

A kite is flying at a height of 60 m above the ground. The string attached to the kite is temporarily tied to a point on the ground. The inclination of the string with the ground is 60° . Find the length of the string, assuming that there is no slack in the string.

Answer 5:



Let K be the kite and the string is tied to point P on the ground.

In $\triangle KLP$,

$$\frac{KL}{KP} = \sin 60^\circ$$

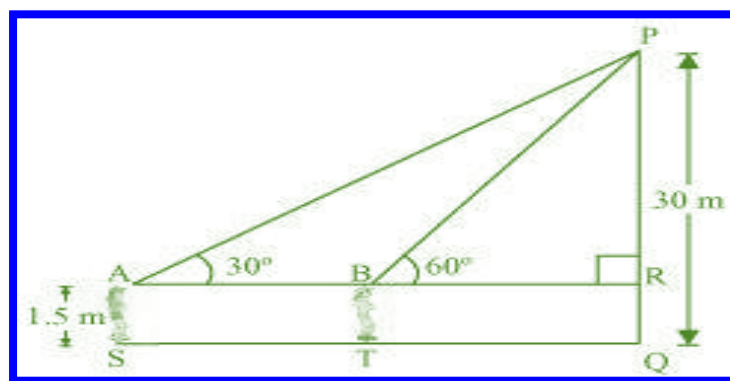
$$\frac{60}{KP} = \frac{\sqrt{3}}{2}$$

$$KP = \frac{120}{\sqrt{3}} = 40\sqrt{3} \text{ m}$$

Hence, the length of the string is $40\sqrt{3}$ m.

Question 6:

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.

Answer 6:

Let the boy was standing at point S initially. He walked towards the building and reached at point T. It can be observed that

$$\begin{aligned} PR &= PQ - RQ \\ &= (30 - 1.5) \text{ m} = 28.5 \text{ m} = \frac{57}{2} \text{ m} \end{aligned}$$

In $\triangle PAR$,

$$\begin{aligned} \frac{PR}{AR} &= \tan 30^\circ \\ \frac{57}{2AR} &= \frac{1}{\sqrt{3}} \\ AR &= \left(\frac{57}{2} \sqrt{3} \right) \text{ m} \end{aligned}$$

In $\triangle PRB$,

$$\begin{aligned} \frac{PR}{BR} &= \tan 60^\circ \\ \frac{57}{2BR} &= \sqrt{3} \\ BR &= \frac{57}{2\sqrt{3}} = \left(\frac{19\sqrt{3}}{2} \right) \text{ m} \end{aligned}$$

$$ST = AB$$

$$= AR - BR = \left(\frac{57\sqrt{3}}{2} - \frac{19\sqrt{3}}{2} \right) \text{m}$$

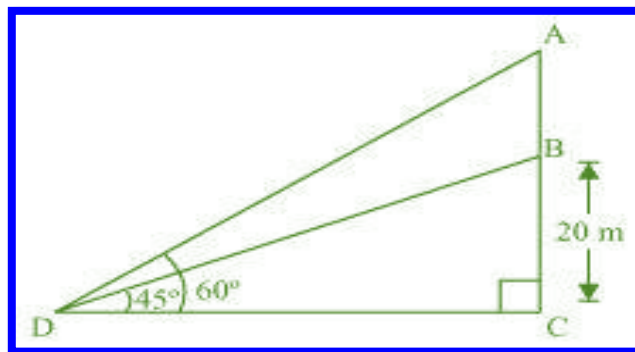
$$= \left(\frac{38\sqrt{3}}{2} \right) \text{m} = 19\sqrt{3} \text{ m}$$

Hence, he walked $19\sqrt{3}$ m towards the building.

Question 7:

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

Answer 7:



Let BC be the building, AB be the transmission tower, and D be the point on the ground from where the elevation angles are to be measured.

In $\triangle BCD$,

$$\frac{BC}{CD} = \tan 45^\circ$$

$$\frac{20}{CD} = 1$$

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

In $\triangle ACD$,

$$\frac{AC}{CD} = \tan 60^\circ$$

$$\frac{AB + BC}{CD} = \sqrt{3}$$

$$\frac{AB + 20}{20} = \sqrt{3}$$

$$AB = (20\sqrt{3} - 20) \text{ m}$$

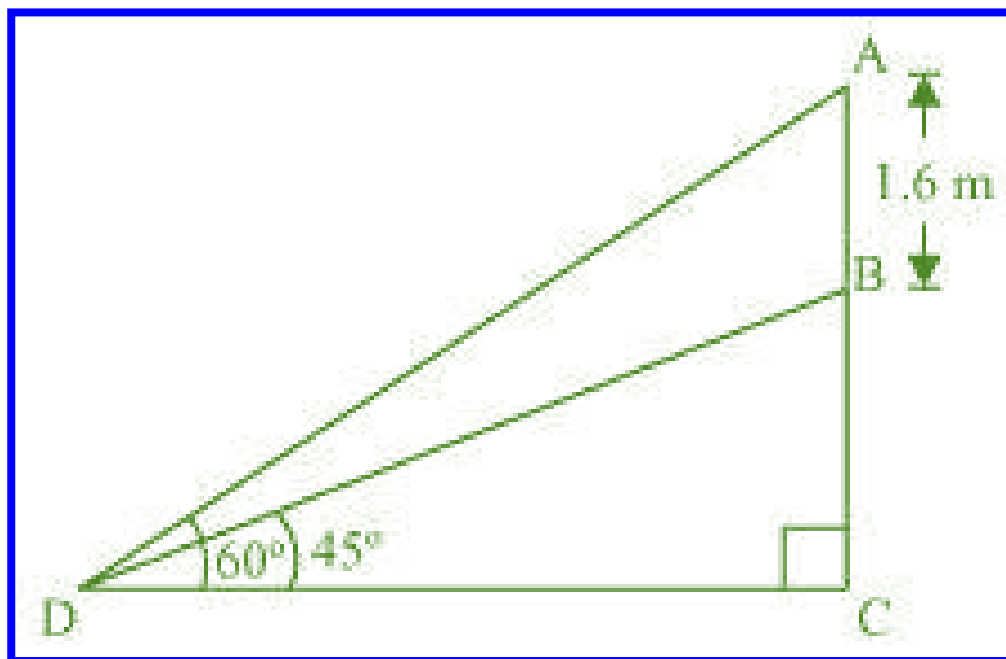
$$= 20(\sqrt{3} - 1) \text{ m}$$

Therefore, the height of the transmission tower is $20(\sqrt{3} - 1)$ m.

Question 8:

A statue, 1.6 m tall, stands on a top of pedestal, from a point on the ground, the angle of elevation of the top of 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.

Answer 8:



Let AB be the statue, BC be the pedestal, and D be the point on the ground from where the elevation angles are to be measured.

In $\triangle BCD$,

$$\frac{BC}{CD} = \tan 45^\circ$$

$$\frac{BC}{CD} = 1$$

$$BC = CD$$

In $\triangle ACD$,

$$\frac{AB + BC}{CD} = \tan 60^\circ$$

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

$$1.6 + BC = BC\sqrt{3}$$

$$BC(\sqrt{3} - 1) = 1.6$$

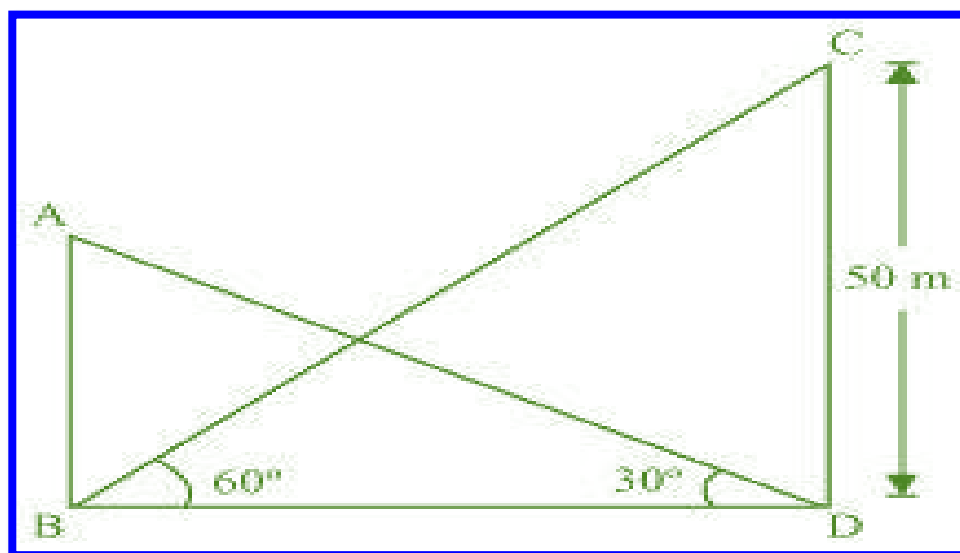
$$\begin{aligned} BC &= \frac{(1.6)(\sqrt{3} + 1)}{(\sqrt{3} - 1)(\sqrt{3} + 1)} \\ &= \frac{1.6(\sqrt{3} + 1)}{(\sqrt{3})^2 - (1)^2} \\ &= \frac{1.6(\sqrt{3} + 1)}{2} = 0.8(\sqrt{3} + 1) \end{aligned}$$

Therefore, the height of the pedestal is $0.8(\sqrt{3} + 1)$ m.

Question 9:

The angle of elevation of the top of a building from the foot of the tower is 30° and the angle of elevation of the top of the tower from the foot of the building is 60° . If the tower is 50 m high, find the height of the building.

Answer 9:



Let AB be the building and CD be the tower.

In $\triangle CDB$,

$$\frac{CD}{BD} = \tan 60^\circ$$

$$\frac{50}{BD} = \sqrt{3}$$

$$BD = \frac{50}{\sqrt{3}}$$

In $\triangle ABD$,

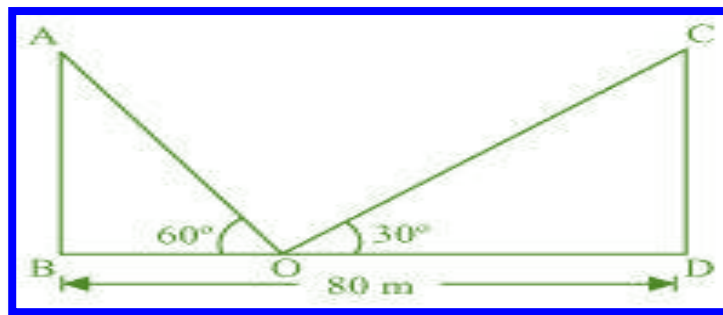
$$\frac{AB}{BD} = \tan 30^\circ$$

$$AB = \frac{50}{\sqrt{3}} \times \frac{1}{\sqrt{3}} = \frac{50}{3} = 16\frac{2}{3}$$

Therefore, the height of the building is $16\frac{2}{3}$ m.

Question 10:

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

Answer 10:

Let AB and CD be the poles and O is the point from where the elevation angles are measured.

In $\triangle ABO$,

$$\frac{AB}{BO} = \tan 60^\circ$$

$$\frac{AB}{BO} = \sqrt{3}$$

$$BO = \frac{AB}{\sqrt{3}}$$

In $\triangle CDO$,

$$\frac{CD}{DO} = \tan 30^\circ$$

$$\frac{CD}{80 - BO} = \frac{1}{\sqrt{3}}$$

$$CD\sqrt{3} = 80 - BO$$

$$CD\sqrt{3} = 80 - \frac{AB}{\sqrt{3}}$$

$$CD\sqrt{3} + \frac{AB}{\sqrt{3}} = 80$$

Since the poles are of equal heights,

$$CD = AB$$

$$CD \left[\sqrt{3} + \frac{1}{\sqrt{3}} \right] = 80$$

$$CD \left(\frac{3+1}{\sqrt{3}} \right) = 80$$

$$CD = 20\sqrt{3} \text{ m}$$

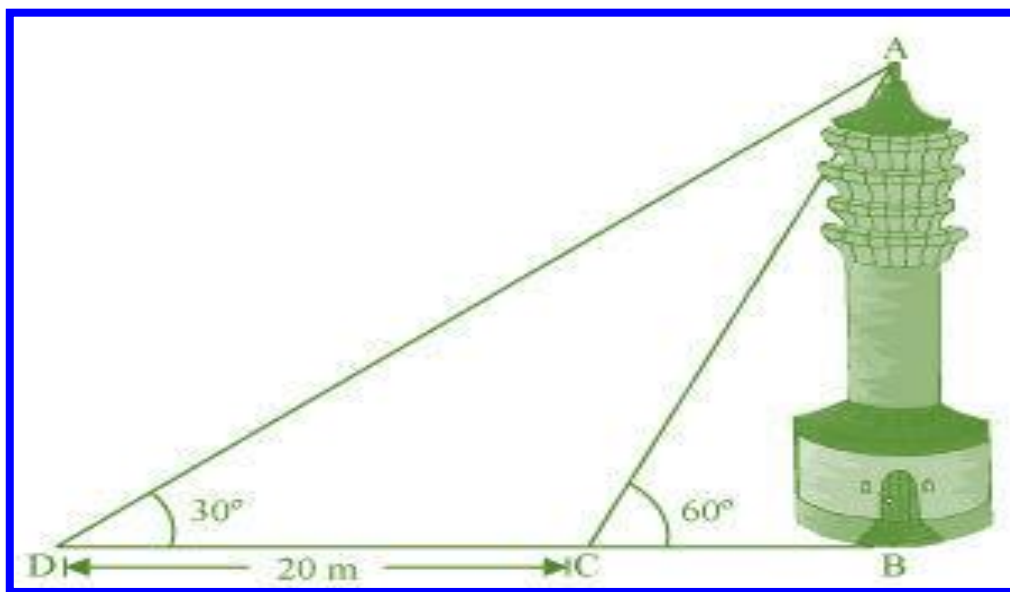
$$BO = \frac{AB}{\sqrt{3}} = \frac{CD}{\sqrt{3}} = \left(\frac{20\sqrt{3}}{\sqrt{3}} \right) \text{ m} = 20 \text{ m}$$

$$DO = BD - BO = (80 - 20) \text{ m} = 60 \text{ m}$$

Therefore, the height of poles is $20\sqrt{3}$ m and the point is 20 m and 60 m far from these poles.

Question 11:

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.



Answer 11:

In $\triangle ABC$,

$$\frac{AB}{BC} = \tan 60^\circ$$

$$\frac{AB}{BC} = \sqrt{3}$$

$$BC = \frac{AB}{\sqrt{3}}$$

In $\triangle ABD$,

$$\frac{AB}{BD} = \tan 30^\circ$$

$$\frac{AB}{BC + CD} = \frac{1}{\sqrt{3}}$$

$$\frac{AB}{\frac{AB}{\sqrt{3}} + 20} = \frac{1}{\sqrt{3}}$$

$$\frac{AB\sqrt{3}}{AB + 20\sqrt{3}} = \frac{1}{\sqrt{3}}$$

$$3AB = AB + 20\sqrt{3}$$

$$2AB = 20\sqrt{3}$$

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

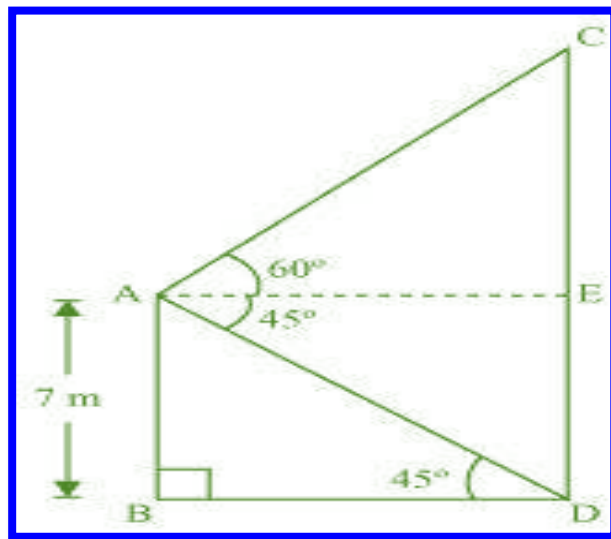
$$BC = \frac{AB}{\sqrt{3}} = \left(\frac{10\sqrt{3}}{\sqrt{3}} \right) \text{ m} = 10 \text{ m}$$

Therefore, the height of the tower is $10\sqrt{3}$ m and the width of the canal is 10 m.

Question 12:

From the top of a 7 m high building, the angle of elevation of the top of a cable tower is 60° and the angle of depression of its foot is 45° . Determine the height of the tower.

Answer 12:



Let AB be a building and CD be a cable tower.

In $\triangle ABD$,

$$\frac{AB}{BD} = \tan 45^\circ$$

$$\frac{7}{BD} = 1$$

$$BD = 7 \text{ m}$$

In $\triangle ACE$,

$$AC = BD = 7 \text{ m}$$

$$\frac{CE}{AE} = \tan 60^\circ$$

$$\frac{CE}{7} = \sqrt{3}$$

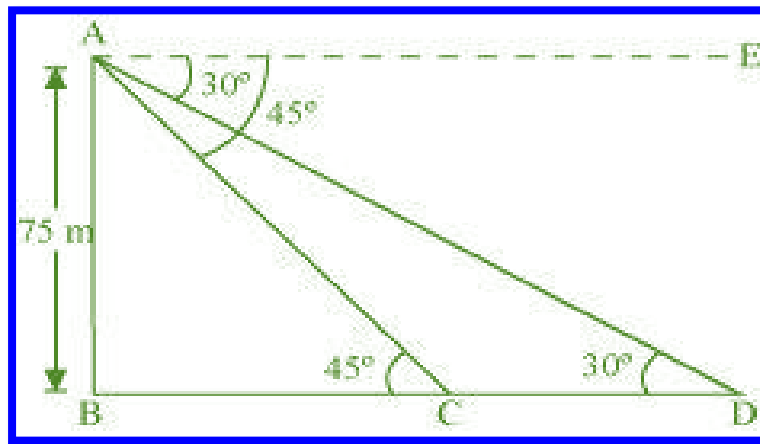
$$CE = 7\sqrt{3} \text{ m}$$

$$\begin{aligned} CD &= CE + ED = (7\sqrt{3} + 7) \text{ m} \\ &= 7(\sqrt{3} + 1) \text{ m} \end{aligned}$$

Therefore, the height of the cable tower is $7(\sqrt{3} + 1)$ m.

Question 13:

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.

Answer 13:

Let AB be the lighthouse and the two ships be at point C and D respectively.

In $\triangle ABC$,

$$\frac{AB}{BC} = \tan 45^\circ$$

$$\frac{75}{BC} = 1$$

$$BC = 75 \text{ m}$$

In $\triangle ABD$,

$$\frac{AB}{BD} = \tan 30^\circ$$

$$\frac{75}{BC + CD} = \frac{1}{\sqrt{3}}$$

$$\frac{75}{75 + CD} = \frac{1}{\sqrt{3}}$$

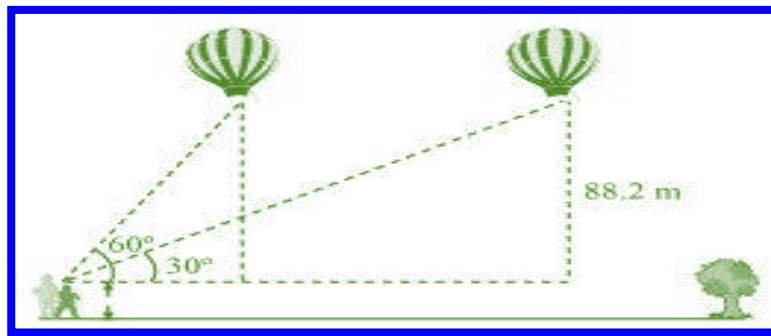
$$75\sqrt{3} = 75 + CD$$

$$75(\sqrt{3} - 1) \text{ m} = CD$$

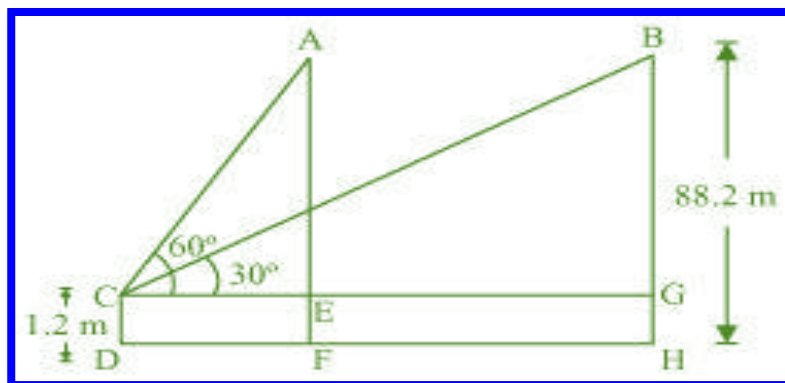
Therefore, the distance between the two ships is $75(\sqrt{3} - 1) \text{ m}$.

Question 14:

A 1.2 m tall girl spots a balloon moving with the wind in a horizontal line at a height of 88.2 m from the ground. The angle of elevation of the balloon from the eyes of the girl at any instant is 60° . After some time, the angle of elevation reduces to 30° . Find the distance travelled by the balloon during the interval.



Answer 14:



Let the initial position A of balloon change to B after some time and CD be the girl.
In $\triangle ACE$,

$$\frac{AE}{CE} = \tan 60^\circ$$

$$\frac{AF - EF}{CE} = \tan 60^\circ$$

$$\frac{88.2 - 1.2}{CE} = \sqrt{3}$$

$$\frac{87}{CE} = \sqrt{3}$$

$$CE = \frac{87}{\sqrt{3}} = 29\sqrt{3} \text{ m}$$

In $\triangle BCG$,

$$\frac{BG}{CG} = \tan 30^\circ$$

$$\frac{88.2 - 1.2}{CG} = \frac{1}{\sqrt{3}}$$

$$87\sqrt{3} \text{ m} = CG$$

Distance travelled by balloon = $EG = CG - CE$

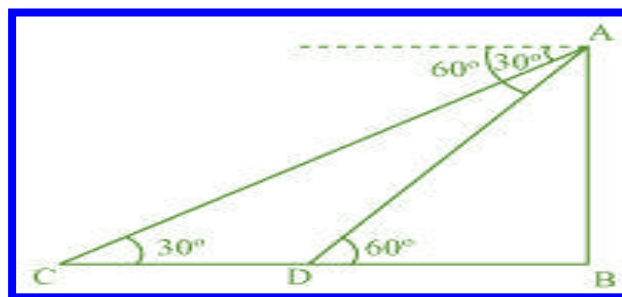
$$= (87\sqrt{3} - 29\sqrt{3}) \text{ m}$$

$$= 58\sqrt{3} \text{ m}$$

Question 15:

A straight highway leads to the foot of a tower. A man standing at the top of the tower observes a car as an angle of depression of 30° , which is approaching the foot of the tower with a uniform 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.

Answer 15:



Let AB be the tower.

Initial position of the car is C, which changes to D after six seconds.

In $\triangle ADB$,

$$\frac{AB}{DB} = \tan 60^\circ$$

$$\frac{AB}{DB} = \sqrt{3}$$

$$DB = \frac{AB}{\sqrt{3}}$$

In $\triangle ABC$,

$$\frac{AB}{BC} = \tan 30^\circ$$

$$\frac{AB}{BD + DC} = \frac{1}{\sqrt{3}}$$

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

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

$$\begin{aligned} DC &= AB\sqrt{3} - \frac{AB}{\sqrt{3}} = AB\left(\sqrt{3} - \frac{1}{\sqrt{3}}\right) \\ &= \frac{2AB}{\sqrt{3}} \end{aligned}$$

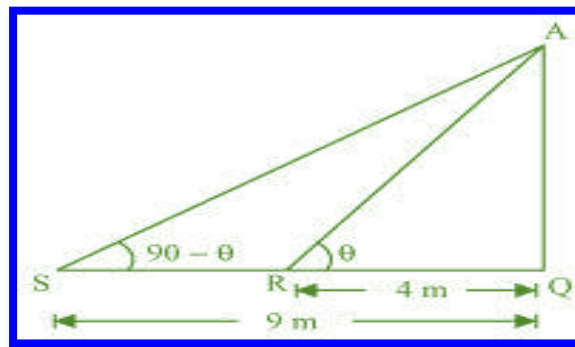
Time taken by the car to travel distance DC = $\left(\text{i.e., } \frac{2AB}{\sqrt{3}}\right)$ 6 seconds Time taken by

the car to travel distance DB $\left(\text{i.e., } \frac{AB}{\sqrt{3}}\right) = \frac{6}{\frac{2AB}{\sqrt{3}}} \times \frac{AB}{\sqrt{3}}$

$$= \frac{6}{2} = 3 \text{ seconds}$$

Question 16:

The angles of elevation of the top of a tower from two points at a distance of 4 m and 9 m. from the base of the tower and in the same straight line with it are complementary. Prove that the height of the tower is 6 m.

Answer 16:

Let AQ be the tower and R, S are the points 4m, 9m away from the base of the tower respectively.

The angles are complementary. Therefore, if one angle is θ , the other will be $90 - \theta$.

In ΔAQR ,

$$\frac{AQ}{QR} = \tan \theta$$

$$\frac{AQ}{4} = \tan \theta \quad \dots (i)$$

In ΔAQS ,

$$\frac{AQ}{SQ} = \tan(90 - \theta)$$

$$\frac{AQ}{9} = \cot \theta \quad \dots (ii)$$

On multiplying equations (i) and (ii), we obtain

$$\left(\frac{AQ}{4} \right) \left(\frac{AQ}{9} \right) = (\tan \theta) \cdot (\cot \theta)$$

$$\frac{AQ^2}{36} = 1$$

$$AQ^2 = 36$$

$$AQ = \sqrt{36} = \pm 6$$

However, height cannot be negative.

Therefore, the height of the tower is 6 m.