EXERCISE 9.1

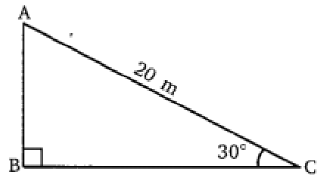
Question 1:

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°.

Solution:

Given: length of the rope (AC) = 20 m, and ∠ACB = 30°

Let height AB of pole be h m.



Then in right ΔABC,

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

$$\Rightarrow \quad \frac{1}{2} = \frac{h}{20} \qquad \left[\because \sin 30^\circ = \frac{1}{2}\right]$$

$$\Rightarrow \quad h = \frac{20}{2} = 10 \text{ m}$$

Hence, height of the pole = 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.

Solution:

Let DB is a tree and AD is the broken part of it which touches the ground at C.

Given: $\angle ACB = 30^\circ$ and $BC = 8$ m

Let $AB = x$ m and $AD = y$ m

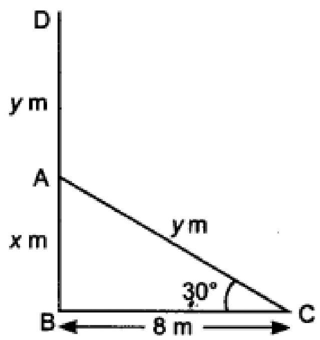
∴ Now, length of the tree $= (x + y)$ m

In ΔABC,

$$\frac{AB}{BC} = \tan 30^\circ \Rightarrow \frac{x}{8} = \frac{1}{\sqrt{3}} \Rightarrow x = \frac{8}{\sqrt{3}} \quad \ldots (i)$$

and $$\frac{AB}{AC} = \sin 30^\circ \Rightarrow \frac{x}{y} = \frac{1}{2}$$

$$\Rightarrow \quad y = 2x \Rightarrow y = 2 \times \frac{8}{\sqrt{3}} = \frac{16}{\sqrt{3}} \quad \text{[From equation (i)]}$$



Hence, total height of the tree

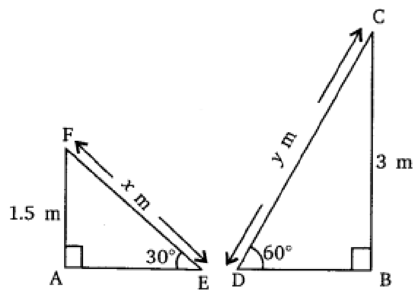
$$x + y = \frac{8}{\sqrt{3}} + \frac{16}{\sqrt{3}} = \frac{24}{\sqrt{3}} = \frac{24}{\sqrt{3}} \times \frac{\sqrt{3}}{\sqrt{3}} = \frac{24\sqrt{3}}{3} = 8 \times 1.732 = 13.856 \text{ m}$$

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 elder children, she wants to have a steep slide 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?

Solution:

Let the length of slide for children below the age of 5 years be x m and length of the slide for elder children be y m.



Given: AF = 1.5 m, BC = 3 m, $\angle FEA = 30°$ and $\angle CDB = 60°$

In right ΔFAE,

$$\sin 30° = \frac{AF}{EF} = \frac{1.5}{x}$$

$$\Rightarrow \quad \frac{1}{2} = \frac{1.5}{x} \quad \Rightarrow \quad x = \mathbf{3\ m}$$

In right ΔCBD,

$$\sin 60° = \frac{BC}{CD} = \frac{3}{y}$$

$$\Rightarrow \quad \frac{\sqrt{3}}{2} = \frac{3}{y} \quad \Rightarrow \quad y = \frac{3 \times 2}{\sqrt{3}} = 2\sqrt{3}\text{ m.}$$

Hence, the length of slide for children below the age of 5 years is 3 m and the length of slide for elder children is $\mathbf{2\sqrt{3}\ m}$.

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.

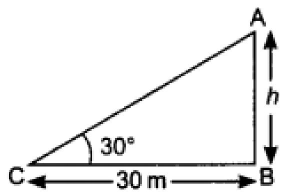
Solution:

Let h be the height of the tower

In ΔABC,

In ΔABC, $\quad \frac{AB}{BC} = \tan 30° \Rightarrow \frac{h}{30} = \frac{1}{\sqrt{3}}$

$$\Rightarrow \quad h = \frac{30}{\sqrt{3}} \times \frac{\sqrt{3}}{\sqrt{3}} = \frac{30\sqrt{3}}{3} = 10\sqrt{3}\text{ m}$$



Question 5:

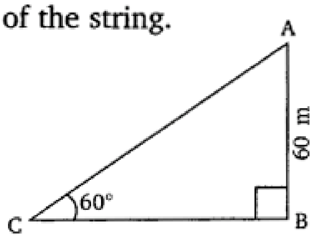
A kite is flying at a height of 60 m above the ground. The string attached to the kite is temporarily tied to a point on the ground. The inclination of the string with the ground is 60°. Find the length of the string, assuming that there is no slack in the string.

Solution:

Given: AB = 60 m and $\angle ACB = 60°$

Let AC be the length of the string.

Then in right ΔABC,



$$\sin 60° = \frac{AB}{AC}$$

$$\Rightarrow \frac{\sqrt{3}}{2} = \frac{60}{AC}$$

$$\Rightarrow AC = \frac{60 \times 2}{\sqrt{3}} \times \frac{\sqrt{3}}{\sqrt{3}} = \frac{120 \times \sqrt{3}}{3} = 40\sqrt{3} \text{ m.}$$

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

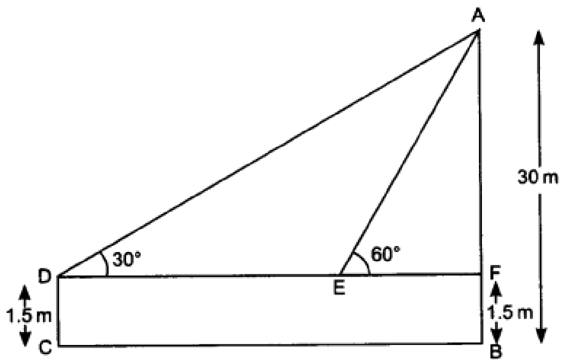
Solution:

Let AB = height of the building

Given: $\angle ADF = 30°$, $\angle AEF = 60°$

$AF = AB - FB$ [$\because$ CD = BF]

$= 30 \text{ m} - 1.5 \text{ m} = 28.5 \text{ m}$



In ΔAFE,

$$\frac{AF}{EF} = \tan 60°$$

$$\Rightarrow \frac{28.5}{EF} = \sqrt{3}$$

$$\Rightarrow EF = \frac{28.5}{\sqrt{3}} \text{ m}$$

In ΔAFD,

$$\frac{AF}{DF} = \tan 30°$$

$$\Rightarrow \frac{28.5}{DF} = \frac{1}{\sqrt{3}}$$

$$\Rightarrow DF = 28.5\sqrt{3} \text{ m}$$

The distance walked by the boy towards building

$$DE = DF - EF$$

$$= 28.5\sqrt{3} - \frac{28.5}{\sqrt{3}} = \frac{28.5 \times 3 - 28.5}{\sqrt{3}} = \frac{28.5(3-1)}{\sqrt{3}}$$

$$= \frac{28.5 \times 2}{\sqrt{3}} \times \frac{\sqrt{3}}{\sqrt{3}} = \frac{57\sqrt{3}}{3} = 19\sqrt{3} \text{ m}$$

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.

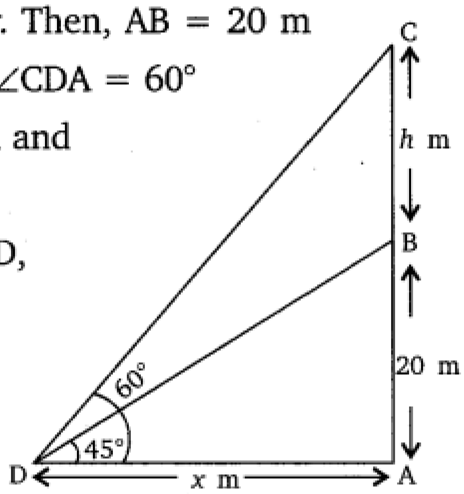
Solution:

Let AB be the building and BC be the transmission tower. Then, AB = 20 m

$\angle BDA = 45^\circ$ and $\angle CDA = 60^\circ$

Also, let DA = x m and

BC = h m



Then in right ΔBAD,

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

$$\Rightarrow \quad 1 = \frac{20}{x}$$

$$\Rightarrow \quad x = 20 \quad \text{...(i)}$$

In right ΔCAD,

$$\tan 60^\circ = \frac{AC}{DA} \quad \Rightarrow \quad \sqrt{3} = \frac{20+h}{x}$$

$$\Rightarrow \quad x = \frac{20+h}{\sqrt{3}} \quad \text{...(ii)}$$

From equations (i) and (ii), we get:

$$\frac{20+h}{\sqrt{3}} = 20 \quad \Rightarrow \quad 20 + h = 20\sqrt{3}$$

$$\Rightarrow \quad h = 20(\sqrt{3} - 1)\text{m.}$$

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

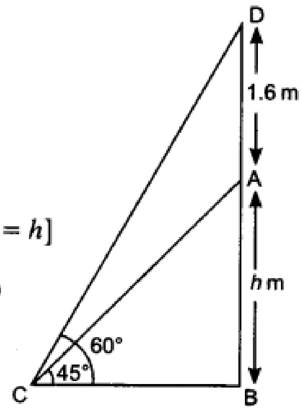
Question 8:

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 height of the pedestal AB = h m

Given: height of the statue = 1.6 m, ∠ACB = 45° and ∠DCB = 60°



In ΔABC, $\frac{AB}{BC} = \tan 45° \Rightarrow \frac{h}{BC} = 1 \Rightarrow BC = h$

In ΔDBC, $\frac{DB}{BC} = \tan 60°$

$\Rightarrow \frac{1.6+h}{h} = \sqrt{3}$ $[\because BC = h]$

$\Rightarrow 1.6 + h = \sqrt{3}h \Rightarrow 1.6 = \sqrt{3}h - h \Rightarrow 1.6 = h(\sqrt{3} - 1)$

$\Rightarrow \frac{1.6}{\sqrt{3}-1} = h \Rightarrow \frac{1.6}{\sqrt{3}-1} \times \frac{\sqrt{3}+1}{\sqrt{3}+1} = h$

$\Rightarrow \frac{1.6(\sqrt{3}+1)}{3-1} = h \Rightarrow \frac{1.6(\sqrt{3}+1)}{2} = h \Rightarrow h = 0.8(\sqrt{3} + 1)$

Hence, height of the pedestal $= 0.8(\sqrt{3} + 1)$m

Question 9:

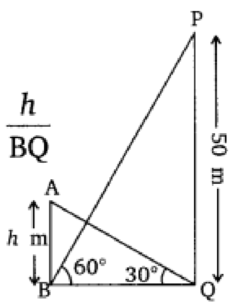
The angle of elevation of the top of a building from the foot of a tower is 30° and the angle of elevation of the top of the tower from the foot of the building is 60°. If the tower is 50 m high, find the height of the building.

Solution:

Given: height of the tower AB = 50 m,

Let h m be the height of the building

Then in right ΔABQ,



$\tan 30° = \frac{AB}{BQ} \Rightarrow \frac{1}{\sqrt{3}} = \frac{h}{BQ}$

$\Rightarrow BQ = h\sqrt{3}$ ... (i)

In right ΔPQB,

$\tan 60° = \frac{PQ}{BQ} \Rightarrow \sqrt{3} = \frac{50}{BQ}$

$\Rightarrow BQ\sqrt{3} = 50 \Rightarrow h\sqrt{3} \times \sqrt{3} = 50$ [From (i)]

$\Rightarrow 3h = 50$

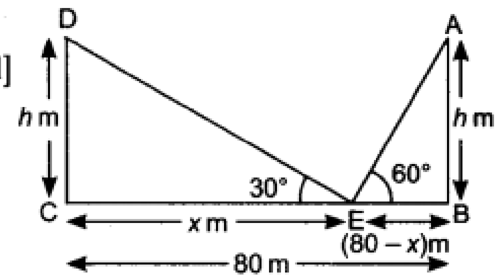
$\Rightarrow h = \frac{50}{3} = 16\frac{2}{3}$ m.

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

Question 10:

Two poles of equal heights are standing opposite each other on 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 the poles and the distance of the point from the poles.

Solution:



Let AB = CD = h m [Height of the poles]

Given: BC = 80 m [Width of the road]

Let CE = x m

$\therefore$ BE = $(80 - x)$ m

In ΔCDE, $\dfrac{CD}{CE} = \dfrac{h}{x} = \tan 30°$

$$\frac{h}{x} = \frac{1}{\sqrt{3}} \Rightarrow x = \sqrt{3}h \quad \text{... }(i)$$

In ΔABE, $\dfrac{AB}{BE} = \tan 60° \Rightarrow \dfrac{h}{80 - x} = \sqrt{3}$

$$\Rightarrow h = 80\sqrt{3} - \sqrt{3}x \Rightarrow \sqrt{3}x = 80\sqrt{3} - h$$

$$\Rightarrow x = \frac{80\sqrt{3} - h}{\sqrt{3}} \quad \text{... }(ii)$$

From equation (i) and (ii), we get

$$\sqrt{3}h = \frac{80\sqrt{3} - h}{\sqrt{3}} \Rightarrow 3h = 80\sqrt{3} - h \Rightarrow 4h = 80\sqrt{3} \Rightarrow h = 20\sqrt{3}$$

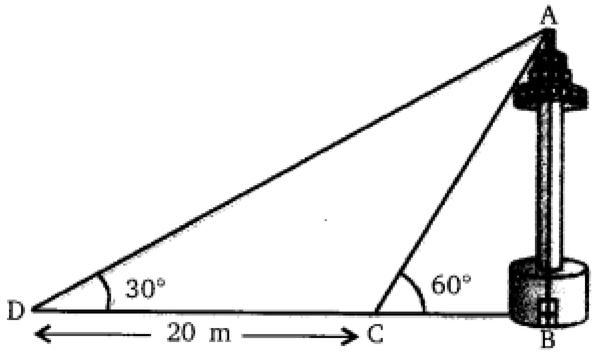
Substituting h in equation (i),

$$x = h\sqrt{3} = 20\sqrt{3} \times \sqrt{3} = 60 \text{ m}$$

Hence, position of the point is at a distance of 60 m from pole CD and 20 m from pole AB.

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° (see the given figure). Find the height of the tower and the width of the CD and 20 m from pole AB.



Solution:

Let the height of the tower AB be h m and x m be the width of the canal BC.

Then in right ΔABD,

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

$$\Rightarrow \quad \frac{1}{\sqrt{3}} = \frac{h}{20+x}$$

$$\Rightarrow \quad 20 + x = h\sqrt{3}$$

$$\Rightarrow \quad x = h\sqrt{3} - 20 \qquad \text{... (i)}$$

In right ΔABC, $\tan 60^\circ = \frac{AB}{BC}$

$$\Rightarrow \quad \sqrt{3} = \frac{h}{x} \quad \Rightarrow \quad x = \frac{h}{\sqrt{3}} \qquad \text{... (ii)}$$

From equations (i) and (ii), we get:

$$h\sqrt{3} - 20 = \frac{h}{\sqrt{3}}$$

$$\Rightarrow \quad h\sqrt{3} - \frac{h}{\sqrt{3}} = 20 \quad \Rightarrow \quad h\left(\frac{3-1}{\sqrt{3}}\right) = 20$$

$$\Rightarrow \quad h = \frac{20\sqrt{3}}{2} = 10\sqrt{3}$$

Putting the value of $h = 10\sqrt{3}$ in equation (ii), we get:

$$x = \frac{h}{\sqrt{3}} = \frac{10\sqrt{3}}{\sqrt{3}} = 10 \text{ m.}$$

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

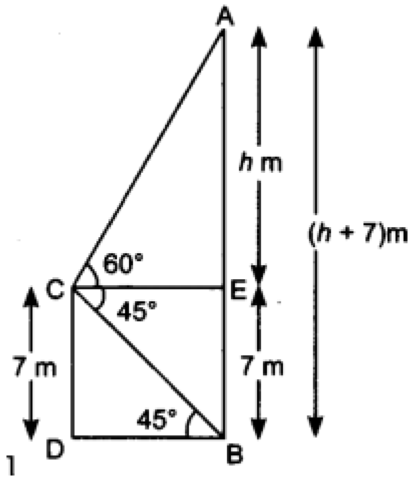
Question 12:

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.

Solution:

Let height of the tower AB = (h + 7) m

Given: CD = 7 m (height of the building),



$\angle ACE = 60°$, and $\angle ECB = 45°$

$\Rightarrow \quad \angle CBD = 45°$

In ΔCDB, $\quad \dfrac{CD}{DB} = \tan 45° \Rightarrow \dfrac{7}{DB} = 1$

$\Rightarrow \quad DB = 7$ m

In ΔAEC, $\quad \dfrac{AE}{CE} = \tan 60°$

$\Rightarrow \quad \dfrac{h}{7} = \sqrt{3} \qquad [\because DB = CE = 7\text{m}]$

$\Rightarrow \quad h = 7\sqrt{3}$ m

Now, $AB = h + 7 = 7\sqrt{3} + 7 = 7(\sqrt{3} + 1)$m

Hence, height of the tower = $7(\sqrt{3} + 1)$m

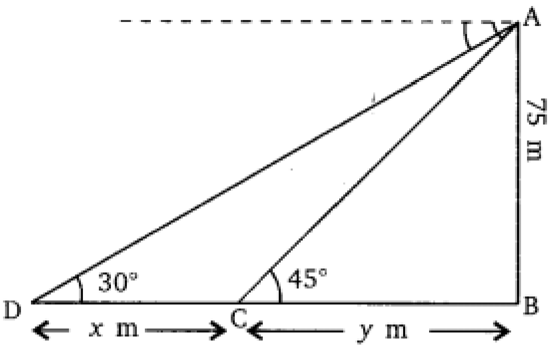
Question 13:

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.

Solution:

Given: $\angle ADB = 30°$, $\angle ACB = 45°$ and AB = 75 m

Let the distance between the ships be x m.



Then in right ΔABC, $\tan 45° = \frac{AB}{BC}$

$\Rightarrow \quad 1 = \frac{75}{y} \quad \Rightarrow \quad y = 75 \text{ m} \quad \text{... (i)}$

In right ΔADB, $\tan 30° = \frac{AB}{BD}$

$\Rightarrow \quad \frac{1}{\sqrt{3}} = \frac{75}{x+y}$

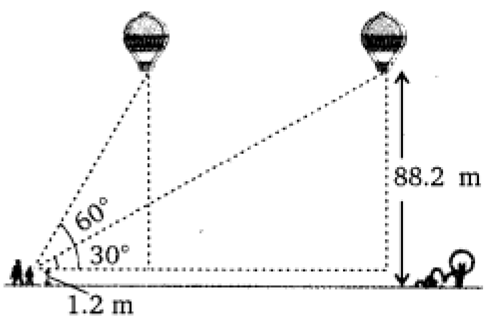
$\Rightarrow x + 75 = 75\sqrt{3}$ [From equation (i)]

$\Rightarrow \quad x = 75\sqrt{3} - 75 = 75(\sqrt{3}-1)$

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

Question 14:

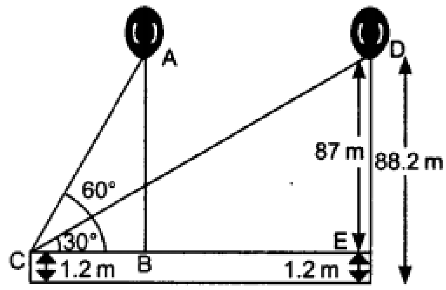
A 1.2 m tall girl spots a balloon moving with the wind in a horizontal line at a height of 88.2 m from the ground. The angle of elevation of the balloon from the eyes of the girl at any instant is 60°. After sometime, the angle of elevation reduces to 30° (see figure). Find the distance travelled by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



Solution:

Let the first position of the balloon is A and after sometime it will reach to the point D.

The vertical height ED = AB = (88.2 – 1.2) m = 87 m.



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

$\Rightarrow \frac{87}{BC} = \sqrt{3} \Rightarrow BC = \frac{87}{\sqrt{3}}$

In ΔDEC, $\frac{DE}{CE} = \tan 30^\circ$

$\Rightarrow \frac{87}{CE} = \frac{1}{\sqrt{3}} \Rightarrow CE = 87\sqrt{3}\,m$

Distance travelled by the balloon from A to D is BE.

So, $BE = CE - CB$

$$= 87\sqrt{3} - \frac{87}{\sqrt{3}} = \frac{87(3-1)}{\sqrt{3}} = \frac{87 \times 2 \times \sqrt{3}}{\sqrt{3} \times \sqrt{3}} = 29 \times 2\sqrt{3} = 58\sqrt{3}\,m$$

Question 15:

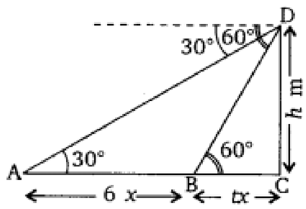
A straight highway leads to the foot of a tower. A man standing at the top of the tower observes a car at an angle of depression of 30°, which is approaching the foot of the tower with a uniform speed. Six seconds later, the angle of depression of the car is found to be 60°. Find the time taken by the car to reach the foot of the tower from this point.

Solution:

Let the height of the tower DC be h m and the speed of the car be x m/s.

Then the distance covered by the car in 6 s will be 6x m.

Also let the time taken by car to move from B to C be t s.



Then the distance BC will be xt m

In right ΔDCB,

$\tan 60^\circ = \frac{DC}{BC} \Rightarrow \sqrt{3} = \frac{h}{tx}$

$\Rightarrow h = \sqrt{3}tx$ ... (i)

In right ΔACD,

$\tan 30^\circ = \frac{DC}{AC} \Rightarrow \frac{1}{\sqrt{3}} = \frac{h}{6x + tx}$

$\Rightarrow 6x + tx = \sqrt{3}h$

$\Rightarrow x(6 + t) = \sqrt{3} \times \sqrt{3}tx$ [From (i)]

$\Rightarrow 6 + t = 3t \Rightarrow 2t = 6$

$\Rightarrow t = 3$ s.

Hence, the required time taken by car is **3 s**.

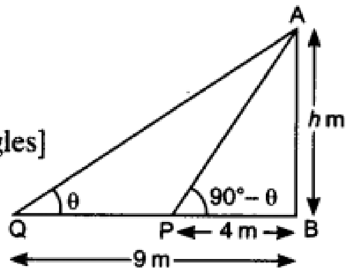
Question 16:

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.

Solution:

Let the height of the tower AB = h m

We have PB = 4 m, QB = 9 m



Let $\angle AQB = \theta$

Then, $\angle APB = 90° - \theta$ [Both are complementary angles]

In ΔABP, $\frac{AB}{PB} = \tan(90° - \theta)$

$\Rightarrow \frac{h}{4} = \cot\theta$

$\Rightarrow h = 4\cot\theta$ ... (i)

In ΔABQ, $\frac{AB}{QB} = \tan\theta$

$\frac{h}{9} = \tan\theta$

$h = 9\tan\theta$ ... (ii)

From equation (i) and (ii), we get

$$h \times h = 4\cot\theta \times 9\tan\theta$$

$$\Rightarrow h^2 = 36\cot\theta \times \tan\theta = 36\frac{1}{\tan\theta} \times \tan\theta$$

$$\Rightarrow h^2 = 36 \Rightarrow h = 6\text{ m}$$

Hence, the height of the tower is 6 m.