Measurement applications: SOHCAHTOA

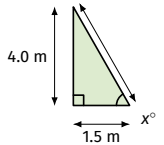
Mana Maths

Opposite and Adjacent

Key idea

Relative to the MARKED angle: the **hypotenuse** is the longest side; the **adjacent** side touches the angle; the **opposite** side does not.

Labelling a ladder problem



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SOHCAHTOA: Finding a Missing Side

Key idea

$\sin = \dfrac{\text{opp}}{\text{hyp}}, \cos = \dfrac{\text{adj}}{\text{hyp}}, \tan = \dfrac{\text{opp}}{\text{adj}}$. Pick the ratio using the angle and the ONE side you know.

A rafter's length

Run (adj) 3.5 m, angle $28°$: $\cos 28° = \dfrac{3.5}{\text{rafter}}$. Rafter $= \dfrac{3.5}{\cos 28°} \approx 3.9$ m.

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Finding a Missing Angle

Key idea

When BOTH the sides you need are known, use the INVERSE function: $\sin^{-1}$, $\cos^{-1}$, or $\tan^{-1}$. Your answer should be between $0°$ and $90°$.

Common mistake

Dividing the two sides and stopping there – you must still apply $\sin^{-1}/\cos^{-1}/\tan^{-1}$ to get the ANGLE.

A ladder's angle

Foot (adj) 1.5 m, height (opp) 4.0 m: $\tan(\text{angle}) = \dfrac{4.0}{1.5}$. Angle $= \tan^{-1}\left(\dfrac{4.0}{1.5}\right) \approx 69.4°$.

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Checking a Trig Result Against a Code

Key idea

A calculated angle can be compared to a LEGAL maximum gradient or a manufacturer's safe-use range – the answer might be "does not comply."

A wheelchair ramp

Angle found $\approx 5.4°$. Legal max $= \tan^{-1}(1/12) \approx 4.8°$. Since $5.4° > 4.8°$, this ramp is TOO STEEP.

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Carry the Full Answer Forward

Using the full-precision length

Rafter $\approx$ 3.964 m. Fascia costs \$12.60/m: use 3.964, not 3.9: $3.964 \times 12.60 \approx \$49.95$.

Common mistake

Rounding the trig answer FIRST, then using the rounded value in a later calculation – this compounds the rounding error. Round only the FINAL answer.

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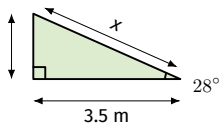
A Carport Roof's Rafter Length

Use SOHCAHTOA to find the missing length. The angle is measured from the horizontal.



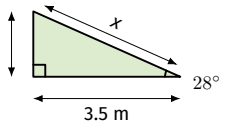
Question 1. A carport roof rises from the low side to the high side at a pitch angle of $28°$. The horizontal run of the roof is 3.5 m, as shown.

(a) Use SOHCAHTOA to calculate the length of the sloping rafter, correct to 1 decimal place.

(b) A fascia board is fitted along the whole length of the rafter, costing $12.60 per metre. Find the total cost, to the nearest cent.

A Carport Roof’s Rafter Length

Use SOHCAHTOA to find the missing length. The angle is measured from the horizontal.



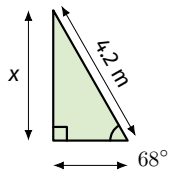
Question 1. A carport roof rises from the low side to the high side at a pitch angle of 28°. The horizontal run of the roof is 3.5 m, as shown.

(a) Use SOHCAHTOA to calculate the length of the sloping rafter, correct to 1 decimal place.
Solution The run (3.5 m) is ADJACENT to the 28° angle, and the rafter is the HYPOTENUSE – use CAH: $\cos 28^\circ = \dfrac{3.5}{\text{rafter}}$, so rafter $= \dfrac{3.5}{\cos 28^\circ} \approx 3.964$ m ≈ 3.9 m (1 d.p.).

(b) A fascia board is fitted along the whole length of the rafter, costing \$12.60 per metre. Find the total cost, to the nearest cent.
Solution Using the full-precision rafter length: $3.964 \times \$12.60 \approx \$49.95$.

A Ladder's Reach Up a Shed Wall

Use SOHCAHTOA to find the missing length. The angle is measured from the ground.



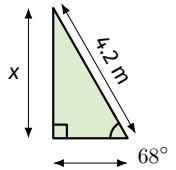
Question 2. A ladder 4.2 m long leans against a shed wall, making an angle of $68°$ with the ground, as shown.

(a) Calculate the height the ladder reaches up the wall, correct to 1 decimal place.

(b) The shed's gutter is 3.8 m above the ground. Does the ladder reach the gutter? Justify your answer using your calculated height.

A Ladder's Reach Up a Shed Wall

Use SOHCAHTOA to find the missing length. The angle is measured from the ground.



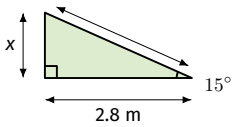
Question 2. A ladder 4.2 m long leans against a shed wall, making an angle of $68°$ with the ground, as shown.

(a) Calculate the height the ladder reaches up the wall, correct to 1 decimal place.
Solution The height is OPPOSITE the $68°$ angle, and the ladder is the HYPOTENUSE – use SOH: $\sin 68° = \dfrac{\text{height}}{4.2}$, so height $= 4.2 \times \sin 68° \approx 3.894$ m ≈ 3.9 m (1 d.p.).

(b) The shed's gutter is 3.8 m above the ground. Does the ladder reach the gutter? Justify your answer using your calculated height.
Solution Using the full-precision height (3.894 m): $3.894 > 3.8$, so yes – the ladder reaches (and slightly overtops) the gutter, by about 0.09 m.

A Loading Ramp's Rise

Use SOHCAHTOA to find the missing length. The angle is measured from the ground.



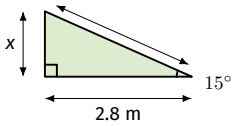
Question 3. A loading ramp for a farm trailer makes an angle of 15° with the ground and has a horizontal run of 2.8 m, as shown.

(a) Calculate the vertical rise of the ramp, correct to 2 decimal places.

(b) The trailer's loading deck is 0.60 m above the ground. Does the ramp rise high enough to reach the deck? Justify your answer.

A Loading Ramp's Rise

Use SOHCAHTOA to find the missing length. The angle is measured from the ground.



Question 3. A loading ramp for a farm trailer makes an angle of 15° with the ground and has a horizontal run of 2.8 m, as shown.

(a) Calculate the vertical rise of the ramp, correct to 2 decimal places.

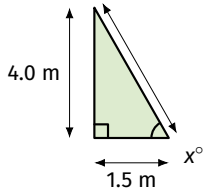
Solution The run (2.8 m) is ADJACENT to the 15° angle, and the rise is OPPOSITE – use TOA: $\tan 15^\circ = \dfrac{\text{rise}}{2.8}$, so rise $= 2.8 \times \tan 15^\circ \approx 0.750$ m ≈ 0.75 m (2 d.p.).

(b) The trailer's loading deck is 0.60 m above the ground. Does the ramp rise high enough to reach the deck? Justify your answer.

Solution Using the full-precision rise (0.750 m): $0.750 > 0.60$, so yes – the ramp rises higher than the deck.

Checking an Extension Ladder's Angle

Use SOHCAHTOA to find the missing angle.



Question 4. An extension ladder's foot is 1.5 m from the wall, and it reaches 4.0 m up the wall, as shown.

(a) Use SOHCAHTOA to calculate the angle the ladder makes with the ground, correct to 1 decimal place.

(b) The ladder's manufacturer states it is safe to use only between $65°$ and $80°$ from the ground. Is this ladder within the safe range?

Checking an Extension Ladder's Angle

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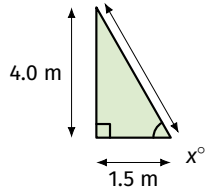


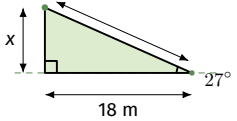
Question 4. An extension ladder's foot is 1.5 m from the wall, and it reaches 4.0 m up the wall, as shown.

(a) Use SOHCAHTOA to calculate the angle the ladder makes with the ground, correct to 1 decimal place.
Solution The 1.5 m foot distance is ADJACENT to the angle at the ground, and the 4.0 m height is OPPOSITE it – use TOA: $\tan(\text{angle}) = \dfrac{4.0}{1.5}$, so angle $= \tan^{-1}\left(\dfrac{4.0}{1.5}\right) \approx 69.444^\circ \approx 69.4^\circ$ (1 d.p.).

(b) The ladder's manufacturer states it is safe to use only between 65° and 80° from the ground. Is this ladder within the safe range?
Solution 69.4° is between 65° and 80°, so yes – the ladder is within the manufacturer's safe range.

A Surveyor's Sight-Line to a Building

Use SOHCAHTOA to find the missing length. The angle of elevation is measured from the horizontal.



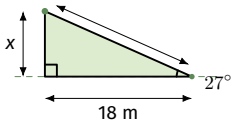
Question 5. A surveyor stands 18 m from the base of a building. The angle of elevation to the top of the building is 27°, as shown.

(a) Calculate the height of the building, correct to 1 decimal place.

(b) A window-cleaning company charges \$18.00 per metre of building height. Using the full-precision height, find the total cost, to the nearest cent.

A Surveyor's Sight-Line to a Building

Use SOHCAHTOA to find the missing length. The angle of elevation is measured from the horizontal.

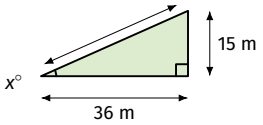


Question 5. A surveyor stands 18 m from the base of a building. The angle of elevation to the top of the building is $27°$, as shown.

(a) Calculate the height of the building, correct to 1 decimal place.
Solution The 18 m distance is ADJACENT to the $27°$ angle of elevation, and the height is OPPOSITE it – use TOA: $\tan 27° = \dfrac{\text{height}}{18}$, so height $= 18 \times \tan 27° \approx 9.172$ m ≈ 9.2 m (1 d.p.).

(b) A window-cleaning company charges \$18.00 per metre of building height. Using the full-precision height, find the total cost, to the nearest cent.
Solution $9.172 \times \$18.00 \approx \$165.09$.

A Zip-Line's Angle of Descent



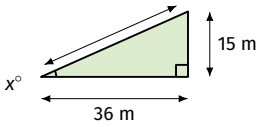
Question 6. A zip-line cable runs from a high platform to a lower platform. The horizontal distance between the platforms is 36 m, and the platforms differ in height by 15 m, as shown.

(a) Decide which trigonometric ratio to use, then calculate the angle the cable makes with the horizontal, correct to 1 decimal place.

(b) Using your angle from (a), calculate the length of cable needed, correct to 1 decimal place.

(c) The cable costs \$6.20 per metre. Find the total cost, to the nearest cent.

A Zip-Line's Angle of Descent



Question 6. A zip-line cable runs from a high platform to a lower platform. The horizontal distance between the platforms is 36 m, and the platforms differ in height by 15 m, as shown.

(a) Decide which trigonometric ratio to use, then calculate the angle the cable makes with the horizontal, correct to 1 decimal place.

Solution Both legs are known (36 m ADJACENT, 15 m OPPOSITE) – use TOA: $\tan(\text{angle}) = \dfrac{15}{36}$, so angle $= \tan^{-1}\left(\dfrac{15}{36}\right) \approx 22.620^\circ \approx 22.6^\circ$ (1 d.p.).

(b) Using your angle from (a), calculate the length of cable needed, correct to 1 decimal place.

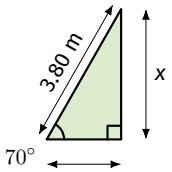
Solution Using the full-precision angle: $\cos 22.620^\circ = \dfrac{36}{\text{cable}}$, so cable $= \dfrac{36}{\cos 22.620^\circ} \approx 39.0$ m (1 d.p.).
(Check: $36^2 + 15^2 = 1296 + 225 = 1521 = 39^2$, confirming the same answer as Pythagoras' theorem.)

(c) The cable costs \$6.20 per metre. Find the total cost, to the nearest cent.

Solution $39.0 \times \$6.20 = \$241.80$.

An Extension Ladder's Reach

Convert all lengths to the same unit before using SOHCAHTOA.



Question 1. An extension ladder 380 cm long leans against a house wall, making an angle of 70° with the ground, as shown.

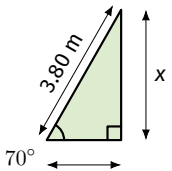
(a) Convert the ladder's length to metres.

(b) Use SOHCAHTOA to calculate the height the ladder reaches up the wall, correct to 1 decimal place.

(c) A window sill is 3.5 m above the ground. Does the ladder reach the sill? Justify your answer.

An Extension Ladder's Reach

Convert all lengths to the same unit before using SOHCAHTOA.



Question 1. An extension ladder 380 cm long leans against a house wall, making an angle of 70° with the ground, as shown.

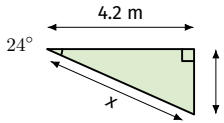
(a) Convert the ladder's length to metres.
Solution 380 cm $= 3.80$ m.

(b) Use SOHCAHTOA to calculate the height the ladder reaches up the wall, correct to 1 decimal place.
Solution The height is OPPOSITE the 70° angle, and the ladder is the HYPOTENUSE – use SOH: $\sin 70^\circ = \dfrac{\text{height}}{3.80}$, so height $= 3.80 \times \sin 70^\circ \approx 3.571$ m ≈ 3.6 m (1 d.p.).

(c) A window sill is 3.5 m above the ground. Does the ladder reach the sill? Justify your answer.
Solution Using the full-precision height (3.571 m): $3.571 > 3.5$, so yes – the ladder reaches the sill, with about 0.07 m to spare.

Does the Rafter Reach the Ridge?

Use SOHCAHTOA to find the sloped length needed, then compare it with the available stock lengths.



Question 2. A gable roof's horizontal half-span is 4.2 m, and the pitch angle is 24°, as shown. Each rafter must also overhang the wall by 0.3 m at the low end (the eave).

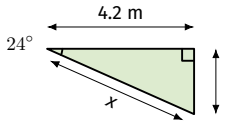
(a) Use SOHCAHTOA to calculate the sloped length needed to reach the ridge, correct to 2 decimal places.

(b) Add the 0.3 m eave overhang. What is the total minimum rafter length needed?

(c) Rafter timber is sold only in precut lengths of 4.2 m, 4.7 m, or 5.4 m. Which length must be bought? Justify your answer using the actual numbers.

Does the Rafter Reach the Ridge?

Use SOHCAHTOA to find the sloped length needed, then compare it with the available stock lengths.



Question 2. A gable roof's horizontal half-span is 4.2 m, and the pitch angle is 24°, as shown. Each rafter must also overhang the wall by 0.3 m at the low end (the eave).

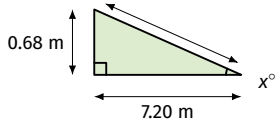
(a) Use SOHCAHTOA to calculate the sloped length needed to reach the ridge, correct to 2 decimal places.
Solution The half-span (4.2 m) is ADJACENT to the 24° angle, and the rafter is the HYPOTENUSE – use CAH: $\cos 24^\circ = \dfrac{4.2}{\text{rafter}}$, so rafter $= \dfrac{4.2}{\cos 24^\circ} \approx 4.5975$ m ≈ 4.60 m (2 d.p.).

(b) Add the 0.3 m eave overhang. What is the total minimum rafter length needed?
Solution Using the full-precision length: $4.5975 + 0.3 \approx 4.8975$ m, so at least 4.90 m is needed.

(c) Rafter timber is sold only in precut lengths of 4.2 m, 4.7 m, or 5.4 m. Which length must be bought? Justify your answer using the actual numbers.
Solution The 4.7 m length is too short ($4.7 < 4.8975$, short by about 0.20 m), so the 5.4 m length must be bought.

Checking a Wheelchair Ramp's Gradient

Use SOHCAHTOA to find the missing angle.



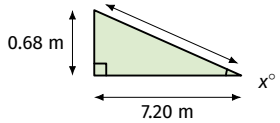
Question 3. A new wheelchair ramp rises 0.68 m over a horizontal run of 7.20 m, as shown.

(a) Use SOHCAHTOA to calculate the angle the ramp makes with the ground, correct to 1 decimal place.

(b) The NZ Building Code requires a wheelchair ramp's gradient to be no steeper than $1{:}12$ (an angle of about $4.8°$). Does this ramp meet the code?

Checking a Wheelchair Ramp's Gradient

Use SOHCAHTOA to find the missing angle.



Question 3. A new wheelchair ramp rises 0.68 m over a horizontal run of 7.20 m, as shown.

(a) Use SOHCAHTOA to calculate the angle the ramp makes with the ground, correct to 1 decimal place.

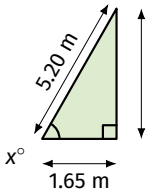
Solution Both legs are known (7.20 m ADJACENT, 0.68 m OPPOSITE) – use TOA: $\tan(\text{angle}) = \dfrac{0.68}{7.20}$, so angle $= \tan^{-1}\left(\dfrac{0.68}{7.20}\right) \approx 5.395^\circ \approx 5.4^\circ$ (1 d.p.).

(b) The NZ Building Code requires a wheelchair ramp's gradient to be no steeper than $1{:}12$ (an angle of about 4.8°). Does this ramp meet the code?

Solution $\tan^{-1}(1/12) \approx 4.8^\circ$. Since $5.4^\circ > 4.8^\circ$, this ramp is TOO STEEP – it does not meet the code.

Checking a Ladder's Footing Distance

Use SOHCAHTOA to find the missing angle.



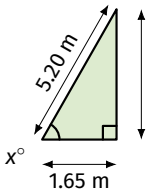
Question 4. An extension ladder is 5.20 m long. Its foot is placed 1.65 m from the wall, as shown.

(a) Use SOHCAHTOA to calculate the angle the ladder makes with the ground, correct to 1 decimal place.

(b) The ladder's manufacturer states it is safe to use only between $65°$ and $80°$ from the ground. Is this ladder within the safe range?

Checking a Ladder's Footing Distance

Use SOHCAHTOA to find the missing angle.



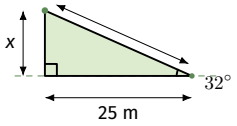
Question 4. An extension ladder is 5.20 m long. Its foot is placed 1.65 m from the wall, as shown.

(a) Use SOHCAHTOA to calculate the angle the ladder makes with the ground, correct to 1 decimal place.
Solution The 1.65 m foot distance is ADJACENT to the angle, and the 5.20 m ladder is the HYPOTENUSE – use CAH: $\cos(\text{angle}) = \dfrac{1.65}{5.20}$, so angle $= \cos^{-1}\left(\dfrac{1.65}{5.20}\right) \approx 71.500^\circ \approx 71.5^\circ$ (1 d.p.).

(b) The ladder's manufacturer states it is safe to use only between 65° and 80° from the ground. Is this ladder within the safe range?
Solution 71.5° is between 65° and 80°, so yes – the ladder is within the manufacturer's safe range.

A Surveyor's Building-Height Survey

Remember to add the surveyor's eye height once you have found the height above eye level.



Question 5. A surveyor's eye is 1.6 m above the ground. Standing 25 m from the base of a building, the angle of elevation from the surveyor's eye to the top of the building is $32°$, as shown.

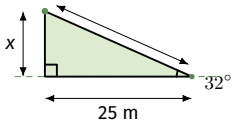
(a) Use SOHCAHTOA to calculate the height of the building above the surveyor's eye level, correct to 1 decimal place.

(b) Add the surveyor's eye height to find the total height of the building, correct to 1 decimal place.

(c) A window-cleaning company charges \$22.00 per metre of total building height. Using the full-precision height, find the total cost, to the nearest cent.

A Surveyor's Building-Height Survey

Remember to add the surveyor's eye height once you have found the height above eye level.



Question 5. A surveyor's eye is 1.6 m above the ground. Standing 25 m from the base of a building, the angle of elevation from the surveyor's eye to the top of the building is 32°, as shown.

(a) Use SOHCAHTOA to calculate the height of the building above the surveyor's eye level, correct to 1 decimal place.

Solution The 25 m distance is ADJACENT to the 32° angle, and the height above eye level is OPPOSITE it – use TOA: $\tan 32^\circ = \dfrac{\text{height}}{25}$, so height $= 25 \times \tan 32^\circ \approx 15.622$ m ≈ 15.6 m (1 d.p.).

(b) Add the surveyor's eye height to find the total height of the building, correct to 1 decimal place.

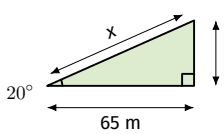
Solution Using the full-precision height: $15.622 + 1.6 \approx 17.222$ m ≈ 17.2 m (1 d.p.).

(c) A window-cleaning company charges \$22.00 per metre of total building height. Using the full-precision height, find the total cost, to the nearest cent.

Solution $17.222 \times \$22.00 \approx \$378.88$.

Choosing a Zip-Line Cable Supplier

Use SOHCAHTOA to find the missing length, then compare the two suppliers.



Question 6. A zip-line's horizontal distance is 65 m, and the cable makes an angle of 20° with the horizontal, as shown.

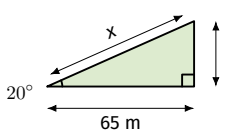
(a) Use SOHCAHTOA to calculate the length of cable needed, correct to 1 decimal place.

(b) Supplier A sells cable continuously at \$5.80 per metre. Supplier B sells a single pre-cut length, up to 75 m, for a flat \$410. Calculate the cost from each supplier, using the full-precision cable length for Supplier A.

(c) Which supplier is cheaper, and by how much?

Choosing a Zip-Line Cable Supplier

Use SOHCAHTOA to find the missing length, then compare the two suppliers.



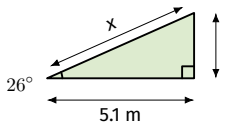
Question 6. A zip-line's horizontal distance is 65 m, and the cable makes an angle of 20° with the horizontal, as shown.

(a) Use SOHCAHTOA to calculate the length of cable needed, correct to 1 decimal place.
Solution The 65 m distance is ADJACENT to the 20° angle, and the cable is the HYPOTENUSE – use CAH: $\cos 20^\circ = \dfrac{65}{\text{cable}}$, so cable $= \dfrac{65}{\cos 20^\circ} \approx 69.172$ m ≈ 69.2 m (1 d.p.).

(b) Supplier A sells cable continuously at \$5.80 per metre. Supplier B sells a single pre-cut length, up to 75 m, for a flat \$410. Calculate the cost from each supplier, using the full-precision cable length for Supplier A.
Solution Supplier A: $69.172 \times \$5.80 \approx \$401.20$. Supplier B: flat $\$410.00$ (the 69.172 m cable fits within the 75 m pre-cut length).

(c) Which supplier is cheaper, and by how much?
Solution Supplier A ($\$401.20$) is cheaper than Supplier B ($\$410.00$), by $\$8.80$.

Cladding a Gable Roof, on Budget



Question 1. A gable-roofed building has a horizontal half-span of 5.1 m, and each rafter's pitch angle is $26°$, as shown. The roof is 10 m deep, with two sloped sides (front and back). The cladding budget is $2100.

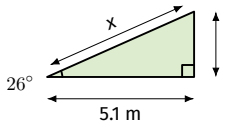
(a) Use SOHCAHTOA to calculate the length of one rafter, correct to 2 decimal places.

(b) Calculate the total area needing cladding (both sloped sides).

(c) Cladding sheets cover 2.4 m^2 each and cost $46 per sheet, sold only in whole sheets. Find how many sheets are needed, and the total cost.

(d) Is the $2100 budget enough? If not, state by how much it falls short.

Cladding a Gable Roof, on Budget



Question 1. A gable-roofed building has a horizontal half-span of 5.1 m, and each rafter's pitch angle is $26°$, as shown. The roof is 10 m deep, with two sloped sides (front and back). The cladding budget is \$2100.

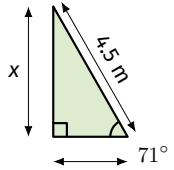
(a) Use SOHCAHTOA to calculate the length of one rafter, correct to 2 decimal places.
Solution The half-span (5.1 m) is ADJACENT to the $26°$ angle, and the rafter is the HYPOTENUSE – use CAH: $\cos 26° = \dfrac{5.1}{\text{rafter}}$, so rafter $= \dfrac{5.1}{\cos 26°} \approx 5.6743$ m ≈ 5.67 m (2 d.p.).

(b) Calculate the total area needing cladding (both sloped sides).
Solution Using the full-precision rafter length: $2 \times 5.6743 \times 10 \approx 113.49$ m^2 (2 d.p.).

(c) Cladding sheets cover 2.4 m^2 each and cost \$46 per sheet, sold only in whole sheets. Find how many sheets are needed, and the total cost.
Solution $113.49 \div 2.4 \approx 47.29$, round UP $= 48$ sheets. Cost $= 48 \times \$46 = \$2208.00$.

(d) Is the \$2100 budget enough? If not, state by how much it falls short.
Solution No – $\$2208.00 > \$2100$, so the budget falls short by $\$108.00$.

Extending a Ladder to Reach a Window



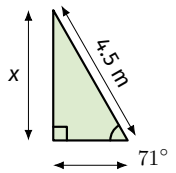
Question 2. An extension ladder 4.5 m long leans against a house wall, making an angle of 71° with the ground, as shown. A window sill that needs reaching is 4.60 m above the ground.

(a) Use SOHCAHTOA to calculate the height the ladder currently reaches, correct to 1 decimal place.

(b) Is the ladder long enough to reach the sill? If not, state the shortfall, correct to 2 decimal places.

(c) A ladder extension is sold only in whole 0.5 m sections, at \$45 per section. Find how many sections are needed, and the total cost.

Extending a Ladder to Reach a Window



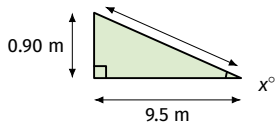
Question 2. An extension ladder 4.5 m long leans against a house wall, making an angle of 71° with the ground, as shown. A window sill that needs reaching is 4.60 m above the ground.

(a) Use SOHCAHTOA to calculate the height the ladder currently reaches, correct to 1 decimal place.
Solution The height is OPPOSITE the 71° angle, and the ladder is the HYPOTENUSE – use SOH: $\sin 71^\circ = \dfrac{\text{height}}{4.5}$, so height $= 4.5 \times \sin 71^\circ \approx 4.2548$ m ≈ 4.3 m (1 d.p.).

(b) Is the ladder long enough to reach the sill? If not, state the shortfall, correct to 2 decimal places.
Solution Using the full-precision height (4.2548 m): $4.60 - 4.2548 \approx 0.35$ m short (2 d.p.) – the ladder does NOT reach.

(c) A ladder extension is sold only in whole 0.5 m sections, at \$45 per section. Find how many sections are needed, and the total cost.
Solution $0.3452 \div 0.5 \approx 0.69$, round UP $= 1$ section. Cost $= 1 \times \$45 = \$45.00$.

Bringing a Wheelchair Ramp Up to Code



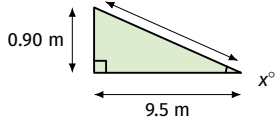
Question 3. A new deck is 0.90 m above ground level. A wheelchair ramp is planned with a horizontal run of 9.5 m, as shown.

(a) Use SOHCAHTOA to calculate the ramp's planned angle, correct to 1 decimal place.

(b) The NZ Building Code requires a wheelchair ramp's gradient to be no steeper than $1{:}12$ (an angle of about $4.8°$). Does this planned ramp meet the code?

(c) If it does not meet the code, calculate the MINIMUM horizontal run needed for a legal $1{:}12$ ramp with the same 0.90 m rise, correct to 1 decimal place, and state how much longer the ramp must be made.

Bringing a Wheelchair Ramp Up to Code



Question 3. A new deck is 0.90 m above ground level. A wheelchair ramp is planned with a horizontal run of 9.5 m, as shown.

(a) Use SOHCAHTOA to calculate the ramp's planned angle, correct to 1 decimal place.

Solution Both legs are known (9.5 m ADJACENT, 0.90 m OPPOSITE) – use TOA: $\tan(\text{angle}) = \dfrac{0.90}{9.5}$, so angle $= \tan^{-1}\left(\dfrac{0.90}{9.5}\right) \approx 5.412^\circ \approx 5.4^\circ$ (1 d.p.).

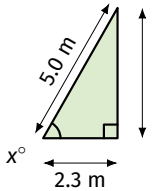
(b) The NZ Building Code requires a wheelchair ramp's gradient to be no steeper than $1{:}12$ (an angle of about 4.8°). Does this planned ramp meet the code?

Solution $\tan^{-1}(1/12) \approx 4.8^\circ$. Since $5.4^\circ > 4.8^\circ$, this ramp is TOO STEEP – it does not meet the code.

(c) If it does not meet the code, calculate the MINIMUM horizontal run needed for a legal $1{:}12$ ramp with the same 0.90 m rise, correct to 1 decimal place, and state how much longer the ramp must be made.

Solution Using the full-precision legal angle (4.7636°): run $= \dfrac{0.90}{\tan 4.7636^\circ} \approx 10.8$ m (1 d.p.). The ramp must be made $10.8 - 9.5 = 1.3$ m longer.

Adjusting a Ladder's Footing Distance



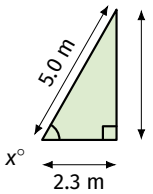
Question 4. An extension ladder is 5.0 m long. Its foot is currently placed 2.3 m from the wall, as shown.

(a) Use SOHCAHTOA to calculate the actual angle the ladder makes with the ground, correct to 1 decimal place.

(b) The ladder's manufacturer states it is safe to use only between $65°$ and $80°$ from the ground. Is this ladder within the safe range?

(c) If it is not, calculate how far the foot must be moved to bring the ladder to exactly the nearer boundary of the safe range, correct to 2 decimal places.

Adjusting a Ladder's Footing Distance



Question 4. An extension ladder is 5.0 m long. Its foot is currently placed 2.3 m from the wall, as shown.

(a) Use SOHCAHTOA to calculate the actual angle the ladder makes with the ground, correct to 1 decimal place.

Solution The 2.3 m foot distance is ADJACENT to the angle, and the 5.0 m ladder is the HYPOTENUSE – use CAH: $\cos(\text{angle}) = \dfrac{2.3}{5.0}$, so angle $= \cos^{-1}\left(\dfrac{2.3}{5.0}\right) \approx 62.613^\circ \approx 62.6^\circ$ (1 d.p.).

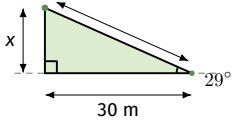
(b) The ladder's manufacturer states it is safe to use only between 65° and 80° from the ground. Is this ladder within the safe range?

Solution No – $62.6^\circ < 65^\circ$, so the ladder is TOO SHALLOW (the foot is too far from the wall).

(c) If it is not, calculate how far the foot must be moved to bring the ladder to exactly the nearer boundary of the safe range, correct to 2 decimal places.

Solution At the nearer boundary, 65°: foot $= 5.0 \times \cos 65^\circ \approx 2.1131$ m. The foot must be moved IN, towards the wall, by $2.3 - 2.1131 \approx 0.19$ m (2 d.p.).

Surveying a Building for a Contract



Question 5. A surveyor's eye is 1.65 m above the ground, standing 30 m from a building's base. The angle of elevation to the top is $29°$, as shown.

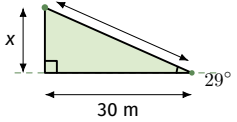
(a) Use SOHCAHTOA to calculate the height of the building above the surveyor's eye level, correct to 1 decimal place.

(b) Add the eye height to find the total height of the building, correct to 1 decimal place.

(c) Calculate the direct line-of-sight distance to the top, correct to 1 decimal place (check with Pythagoras' theorem).

(d) Contractor A charges \$30.00 per metre of height. Contractor B charges a flat \$650 up to 20 m, plus \$40.00 per extra metre. Which is cheaper here?

Surveying a Building for a Contract



Question 5. A surveyor's eye is 1.65 m above the ground, standing 30 m from a building's base. The angle of elevation to the top is $29°$, as shown.

(a) Use SOHCAHTOA to calculate the height of the building above the surveyor's eye level, correct to 1 decimal place.

Solution The 30 m distance is ADJACENT to the $29°$ angle, and the height above eye level is OPPOSITE it – use TOA: height $= 30 \times \tan 29° \approx 16.629$ m ≈ 16.6 m (1 d.p.).

(b) Add the eye height to find the total height of the building, correct to 1 decimal place.

Solution $16.629 + 1.65 \approx 18.279$ m ≈ 18.3 m (1 d.p.).

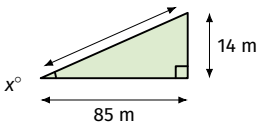
(c) Calculate the direct line-of-sight distance to the top, correct to 1 decimal place (check with Pythagoras' theorem).

Solution CAH: sight-line $= \dfrac{30}{\cos 29°} \approx 34.3$ m (1 d.p.). Pythagoras check: $\sqrt{30^2 + 16.629^2} \approx 34.301$ m – matches.

(d) Contractor A charges \$30.00 per metre of height. Contractor B charges a flat \$650 up to 20 m, plus \$40.00 per extra metre. Which is cheaper here?

Solution Total height 18.279 m (under 20 m). A: $18.279 \times \$30.00 \approx \$548.38$. B: flat $\$650.00$. A is cheaper, by about $\$101.62$.

Certifying a Zip-Line Course



Question 6. A zip-line course has a horizontal run of 85 m between platforms that differ in height by 14 m, as shown. Course safety rules require a descent angle between 8° and 20°.

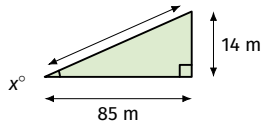
(a) Use SOHCAHTOA to calculate the descent angle, correct to 1 decimal place.

(b) Does this course meet the 8°-20° safety rule?

(c) Use SOHCAHTOA (or Pythagoras' theorem as a check) to calculate the length of cable needed, rounded UP to the next whole metre.

(d) Cable costs \$7.40 per metre (whole metres only), plus a fixed \$250 rigging fee. With a \$950 budget, is there enough money? Justify your answer using the actual cost.

Certifying a Zip-Line Course



Question 6. A zip-line course has a horizontal run of 85 m between platforms that differ in height by 14 m, as shown. Course safety rules require a descent angle between 8° and 20°.

(a) Use SOHCAHTOA to calculate the descent angle, correct to 1 decimal place.

Solution Both legs are known (85 m ADJACENT, 14 m OPPOSITE) – use TOA: $\tan(\text{angle}) = \dfrac{14}{85}$, so angle $= \tan^{-1}\left(\dfrac{14}{85}\right) \approx 9.353^\circ \approx 9.4^\circ$ (1 d.p.).

(b) Does this course meet the 8°-20° safety rule?

Solution Yes – 9.4° is between 8° and 20°.

(c) Use SOHCAHTOA (or Pythagoras' theorem as a check) to calculate the length of cable needed, rounded UP to the next whole metre.

Solution Using the full-precision angle: CAH: $\cos 9.353^\circ = \dfrac{85}{\text{cable}}$, so cable $= \dfrac{85}{\cos 9.353^\circ} \approx 86.145$ m. Pythagoras check: $\sqrt{85^2 + 14^2} \approx 86.145$ m – matches. Rounded UP $= 87$ m.

(d) Cable costs \$7.40 per metre (whole metres only), plus a fixed \$250 rigging fee. With a \$950 budget, is there enough money? Justify your answer using the actual cost.

Solution Cost $= 87 \times \$7.40 + \$250 = \$643.80 + \$250 = \$893.80$. Since $\$893.80 \leq \$950$, yes – there is enough money, with $\$56.20$ to spare.