### Students learn to:

<table>
<thead>
<tr>
<th>Emerging</th>
<th>Developing</th>
<th>Mastered</th>
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</thead>
<tbody>
<tr>
<td>Use trigonometric relationships for complementary angles.</td>
<td>Use trigonometric relationships for complementary angles and for ( \tan \theta = \frac{\sin \theta}{\cos \theta} ).</td>
<td>Use trigonometric relationships for complementary angles, ( \tan \theta = \frac{\sin \theta}{\cos \theta} ), and determine trigonometric ratios for obtuse angles.</td>
</tr>
</tbody>
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### Learning Outcomes

<table>
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<tr>
<td><strong>Learning Outcome</strong></td>
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<tr>
<td>Find the length of an unknown side using right-angled trigonometry.</td>
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<th>10T1.2</th>
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<tr>
<td><strong>Learning Outcome</strong></td>
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<tr>
<td>Find the length of an unknown side and an unknown angle using right-angled trigonometry and use to solve problems.</td>
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<tr>
<td><strong>Learning Outcome</strong></td>
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<tr>
<td>Find the area of a triangle using two sides and the included angle.</td>
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<tr>
<td><strong>Learning Outcome</strong></td>
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<tr>
<td>Find the length of an unknown side and an unknown angle using the Sine Rule and use to solve problems.</td>
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<th>10T1.5</th>
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<tr>
<td><strong>Learning Outcome</strong></td>
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<tr>
<td>Find the length of an unknown side and an unknown angle using the Cosine Rule and use to solve problems.</td>
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</table>
Identify the rules to be used in problems

Learning Outcomes

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<td>Emerging</td>
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<tr>
<td><strong>Identify the rules</strong> to be used in problems</td>
<td>Identify the rules to be used and solve problems</td>
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</table>

10T1.1

\[
\begin{align*}
\sin B &= \frac{y}{z} \\
\cos B &= \frac{x}{z} \\
\sin A &= \frac{x}{z} \\
\cos A &= \frac{y}{z}
\end{align*}
\]

Therefore, \( \sin A = \cos B \) and \( \cos A = \sin B \)

The angles in a triangle add to 180°

\[
A + B + 90° = 180°
\]

Therefore, \( A = 90° - B \)

\[
\begin{align*}
\sin A &= \cos(90° - A) \\
\cos A &= \sin(90° - A)
\end{align*}
\]

Find the value of \( x \) in the following:

- \( x = 50 \) \( \sin 40° = \cos x° \)
- \( x = 25 \) \( \sin 65° = \sin x° \)
\[ x = z \sin \theta \quad \sin \theta = \frac{x}{z} \]
\[ y = z \cos \theta \quad \cos \theta = \frac{y}{z} \]

\[ \tan \theta = \frac{x}{y} \]
\[ \tan \theta = \frac{z \sin \theta}{z \cos \theta} \]
\[ \tan \theta = \frac{\sin \theta}{\cos \theta} \]

**Write each of the following in terms of \( \tan \theta \):**

- \( \tan 30° \)
- \( \tan 43° \)

**Solution:**

\[ \sin(180° - \theta) = \sin \theta \]
\[ \cos(180° - \theta) = -\cos \theta \]
\[ \tan(180° - \theta) = -\tan \theta \]

**What acute angle has the same sine as 160°?**

**Solution:**

\[ \sin(180° - A) = \sin A \]
\[ 180° - A = 160° \]
\[ A = 20° \]
\[ \therefore \sin 20° = \sin 160° \]

**Which of the following is the same as \( \tan 140° \)?**

A. \( \tan 40° \)  
B. \( \tan 100° \)  
C. \( -\tan 40° \)  
D. \( -\tan 140° \)
In Grade 9, students learnt to find sides and angles using right-angled trigonometry. In Grade 10, students have the opportunity to revise these skills as they are required to understand how the other trigonometric formulae have been generated and also need to be used in problems involving multiple steps and/or triangles.

For Emerging students must find the unknown side. Students need to be able to select and use the appropriate trigonometric ratio to find an unknown side of a right-angled triangle. To select an appropriate formula, they label the two sides they are working with as either adjacent (A), opposite (O) or hypotenuse (H). They then decide which of the mnemonics SOH, CAH, or TOA uses these two sides. They are finding any unknown side by substituting into the appropriate formula and then rearranging to solve.

Students must realize that the sides opposite and adjacent vary, depending on what angle is selected e.g.

There are two types of equation that can arise when calculating a side from a right angled triangle. One type requires multiplication as the unknown side is the numerator in the ratio fraction. The other type requires division as the unknown side is the denominator in the ratio fraction e.g.

Using SOH
\[
\sin 40° = \frac{O}{H} \\
\sin 40° = \frac{x}{12} \\
12 \times \sin 40° = x \\
x = 7.71 \text{ cm}
\]

Using TOA
\[
\tan 25° = \frac{A}{x} \\
\tan 25° = \frac{5}{x} \\
x \times \tan 25° = 5 \\
x = \frac{5}{\tan 25°} \\
x = 10.7 \text{ cm}
\]
For Developing, students need to also be able to find an unknown angle. Students need to be able to select and use the appropriate trigonometric ratio to find an unknown angle of a right-angled triangle. To select an appropriate formula, they label the two sides they are working with as either adjacent (A), opposite (O) or hypotenuse (H). They then decide which of the mnemonics SOH, CAH, or TOA uses these two sides. They convert the trigonometric ratio into an angle by using the inverse trig keys on their calculator (\( \sin^{-1} A, \cos^{-1} A \text{ or } \tan^{-1} A \)) e.g.

Using CAH

\[
\cos X = \frac{A}{H} \\
\cos X = \frac{6.2}{12} \\
X = \cos^{-1} \left( \frac{6.2}{12} \right) \\
X = 58.9^\circ
\]

For Mastered, students must have the opportunity to solve problems in context for both finding a side and finding an angle e.g.

Finding a side:

\[
\sin 25^\circ = \frac{O}{H} \\
\sin 25^\circ = \frac{h}{6} \\
6 \times \sin 25^\circ = h \\
h = 2.5 \text{ m}
\]

A ship at sea observes a building on top of a 50 m cliff at an angle of 8\(^\circ\). How far out to sea is the ship?

Stand 30 m from a tree (flagpole, building) and use a clinometer to find the angle of elevation to the top of the tree. Then use trigonometry to find the height of the tree.

Students should also have the opportunity to do practical measuring tasks using measuring equipment and calculate unknown lengths using trigonometry, e.g.

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X = 58.9^\circ
\]

A builder is constructing a slide.
- The slide is 6 m long.
- The slide meets the ground at an angle of 25\(^\circ\).

How high is the top of the slide above the ground?

A ship at sea observes a building on top of a 50 m cliff at an angle of 8\(^\circ\). How far out to sea is the ship?

Stand 30 m from a tree (flagpole, building) and use a clinometer to find the angle of elevation to the top of the tree. Then use trigonometry to find the height of the tree.
### Finding an angle:

- **Finding an angle:**
  
  \[ \sin A = \frac{7}{0.75} \]
  
  \[ \sin A = \frac{0.75}{7} \]
  
  \[ A = \sin^{-1} \left( \frac{0.75}{7} \right) \]
  
  \[ A = 6.2^\circ \text{ (2sf)} \]

### For Mastered, students should have the opportunity to solve problems where they need to draw their own diagram and also problems that involve multiple steps e.g.

**Example 1:**

A 4.5 m ladder is used to reach a window 3 m above the ground. What angle must the ladder be placed at if it is to reach the window?

**Example 2:**

A set of stairs for a deck which is 5 metres high, make an angle of 30° with the ground. How far out from the deck do the stairs reach?

**Example 3:**

Saeed’s class is outside measuring for a mathematics project. They measure a tree as 1.6 m tall and then they measure its shadow as 2.5 m long. A short time later, they measure the shadow again and now it is 1.9 m long. What change has there been to the angle of elevation to the sun during this time?

**Solution**

\[ \theta_1 = \tan^{-1} \left( \frac{1.6}{2.5} \right) \]

\[ \theta_1 = 32.6^\circ \]

\[ \theta_2 = \tan^{-1} \left( \frac{1.6}{1.9} \right) \]

\[ \theta_2 = 40.1^\circ \]

\[ \theta_2 - \theta_1 = 40.1 - 32.6 \]

\[ = 7.5^\circ \]
Students should also have the opportunity to do practical measuring tasks using measuring equipment and calculate unknown angles using trigonometry. The example above could be carried out as a practical measuring task.

Students need to learn to reduce rounding error where possible. This means in all calculations, students should keep the full number on their calculator and use it in all calculations. If students round early and use rounded numbers in further calculations, they risk introducing rounding error.

Students also need to round answers sensibly at the end of calculations.
In previous grades, students learnt to find the area of a triangle when they were given the base and the perpendicular height. This is the first time that students have learnt to find the area of a triangle using two sides and the included angle.

It is very important that students understand that they must have two sides and the included angle when using this formula. The included angle means the one that is between the two known sides.

For Emerging, students need to be able to correctly label the sides and angles in a triangle. Students should have the opportunity to use a variety of letters and not always to use A, B and C. When labelling, capital letters are used for the angles and corresponding small letters for the sides opposite the angles e.g.

It is useful for students to understand that the longest side is opposite the largest angle, the medium side is opposite the medium angle and the smallest side is opposite the smallest angle. This allows students to consider whether their answer is reasonable when performing calculations.

Students should have the opportunity to see where the area formula is derived from. It is not required for students to reproduce this explanation e.g.

The area of \(\triangle ABC\) is: 

\[
\text{Area} = \frac{1}{2} \times \text{base} \times \text{height}
\]

\[
\text{Area} = \frac{1}{2} \times BC \times AD
\]

Using trigonometry, we know that:

\[
\sin C = \frac{AD}{AC}
\]

So,

\[
AD = AC \times \sin C
\]

We substitute this into the area formula:

\[
\text{Area} = \frac{1}{2} \times BC \times AC \times \sin C
\]

In the diagram we can see that:

\[
BC = a \quad \text{and} \quad AC = b
\]

Therefore,

\[
\text{Area} = \frac{1}{2} \times a \times b \times \sin C
\]

\[
\text{Area} = \frac{1}{2}ab \sin C
\]
**For Developing**, students need to be able to label the triangle and use the formula to calculate the area of the triangle e.g.

\[
\text{Area} = \frac{1}{2} \times \text{base} \times \text{height} \\
\text{Area} = \frac{1}{2} \times 3.5 \times 4.8 \times \sin 38^\circ \\
\text{Area} = 5.17 \text{ km}^2
\]

**For Mastered**, students need to be able to solve problems which may include drawing the diagram and/or multiple steps e.g.

A builder has been asked to make a merry-go-round and needs to calculate how much wood he will require. From the centre to the outside corner is 1.5 m and the angle of each triangle at the centre is 60°. Find the total area of the merry-go-round.

A builder has been asked to make a merry-go-round and needs to calculate how much wood he will require. From the centre to the outside corner is 1.5 m and the angle of each triangle at the centre is 60°. Find the total area of the merry-go-round.

![View of the merry-go-round from above](image)

<table>
<thead>
<tr>
<th>Merry-go-round in a children's playground</th>
<th>لعبة الدوّار في ملعب الأطفال</th>
<th>View of the merry-go-round from above</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution</td>
<td>مساحة مثلث الواحد</td>
<td>الحل</td>
</tr>
<tr>
<td>Area of one triangle:</td>
<td>المساحة الكلية للعبة الدوّار الخشبيّة</td>
<td>Total area = (0.97 \times 6)</td>
</tr>
<tr>
<td>Total area of the merry-go-round:</td>
<td></td>
<td>Total area = 5.8 m²</td>
</tr>
</tbody>
</table>
10T1.4

- This is the first time students have learnt how to find the length of a side or an angle in a non-right-angled triangle.
- In Cycle 2, students were not introduced to Greek letters. In Cycle 3, they will have opportunities to use common Greek letters e.g. \( \theta, \alpha, \beta, \mu, \sigma \) etc.
- Students need to label the triangle with capital letters for the angles and the opposite sides with the corresponding lower case letter as for the previous LO (10T1.3).
- Students need to understand that the Sine Rule can be used when (including the unknown) you have 2 sides and 2 angles. This will become clearer once they have learnt the Cosine Rule in the next LO.

Students should have the opportunity to see where the area formula is derived from. It is not required for students to reproduce this explanation e.g.

\[
\text{In } \triangle ACD: \\
\sin A = \frac{h}{b} \\
h = b \sin A \\
\text{In } \triangle BCD: \\
\sin B = \frac{h}{a} \\
h = a \sin B \\
\text{Since } h = b \sin A \text{ and } h = a \sin B: \\
b \sin A = a \sin B \\
\text{Therefore} \\
\frac{a}{\sin A} = \frac{b}{\sin B} \\
\text{and} \\
\frac{a}{\sin A} = \frac{b}{\sin B} \\
\]

**It is important that students understand that there are two forms of the Sine Rule, one that is useful when finding unknown sides and the other is useful for finding unknown angles e.g.**

For **finding a side:**

\[
\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c} 
\]

For **Emerging**, students need to calculate the length of an unknown side e.g.

\[
\text{Find the length of } x 
\]

**For finding an angle:**

\[
\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} 
\]

For **Emerging**, students need to calculate the length of an unknown side e.g.

\[
\text{Find the length of } x 
\]

بالنسبة للمستوى المتقدم: يحتاج الطالب إلى حساب طول ضلع مجهول، مثال ذلك:

\[
\text{أوجد طول } x 
\]
**Solution:**

1. **Step 1:** Label the triangle

   \[
   \frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}
   \]

2. **Step 2:** Choose which form of the formula to use

   \[
   \frac{x \sin 51^\circ}{\sin 76^\circ} = \frac{13}{x} = 10.4 \text{ cm}
   \]

3. **Step 3:** Substitute the values into the formula

4. **Step 4:** Solve for \(x\)

\[
\sin \theta = \frac{22 \times \sin 38^\circ}{15}
\]

\[
\sin \theta = 0.9029
\]

\[
\theta = \sin^{-1} 0.9029
\]

\[
\theta = 64.6^\circ
\]

We can expect angle \(\theta\) to be larger than \(38^\circ\) because the side opposite \(\theta\) is 22 cm which is larger than 15 cm (opposite \(38^\circ\)). It is reasonable for angle \(\theta\) to be 64.6°.

5. **Step 5:** Is the answer reasonable?

We know the largest side is opposite the largest angle e.g. 13 cm is opposite 76°, so side \(x\) needs to be smaller than 13 cm since it is opposite a smaller angle. Therefore 10.4 cm is a reasonable answer for the length of side \(x\).

For Developing, students also need to calculate the size of an unknown angle e.g.

\[
\text{Find the size of angle } \theta
\]

\[
\text{\(22 \times \sin 38^\circ / 15\)}
\]

\[
\text{\(0.9029\)}
\]

\[
\text{\(64.6^\circ\)}
\]

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For Developing, students also need to calculate the size of an unknown angle e.g.

\[
\text{Find the size of angle } \theta
\]

\[
\theta = \sin^{-1} 0.9029
\]

\[
\theta = 64.6^\circ
\]

We can expect angle \(\theta\) to be larger than \(38^\circ\) because the side opposite \(\theta\) is 22 cm which is larger than 15 cm (opposite \(38^\circ\)). It is reasonable for angle \(\theta\) to be 64.6°.
For **Mastered**, students need to solve problems involving finding unknown sides and angles e.g.

Khalifa sees his falcon flying at an angle of elevation of 37°. Khalifa also sees a houbara on the ground 25 m away. The angle of elevation of the falcon from the houbara is 43°. Find the distance from the houbara to the falcon (x) and from Khalifa to the falcon (y).

**Solution:**

We need to find the third angle in the triangle. We know that the sum of the angles in a triangle is 180°. 

<table>
<thead>
<tr>
<th>Angle F = 180° − 43° − 37°</th>
<th>Angle F = 100°</th>
</tr>
</thead>
</table>

Find the length of side x

\[ x = \frac{25}{\sin 37°} = \frac{25 \times \sin 37°}{\sin 100°} \]

\[ x = 15.3 \text{ m} \]

Find the length of side y

\[ y = \frac{25}{\sin 43°} = \frac{25 \times \sin 43°}{\sin 100°} \]

\[ y = 17.3 \text{ m} \]

Students also need to be aware of the ambiguous case when using the Sine Rule. Ambiguous means ‘capable of two meanings’. In the situation with the Sine Rule, this means that there are two possible triangles that can be drawn with the given measurements and two possible values for the angle e.g.

A triangle has the measurements: \( A = 36°, a = 4 \text{ cm} \) and \( c = 6 \text{ cm} \). There are two possible ways to draw this triangle e.g.

### Diagram 1

In this triangle, angle C is an obtuse angle

\[ \frac{\sin C}{c} = \frac{\sin A}{a} \]

\[ \sin C = \frac{\sin 36° \times 6}{4} \]

\[ \sin C = 0.8817 \]

\[ C = 61.8° \]

This answer \( C = 61.8° \) is acute and so it fits the second triangle. The two possible answers for angle C add to 180°. This means we can find angle C for the first triangle e.g.

### Diagram 2

In this triangle, angle C is an acute angle

\[ \sin C = \frac{\sin 36° \times 6}{4} \]

This answer \( C = 180° − 61.8° \) is acute and so it fits the second triangle. The two possible answers for angle C add to 180°. This means we can find angle C for the first triangle e.g.

This answer \( C = 61.8° \) is acute and so it fits the second triangle. The two possible answers for angle C add to 180°. This means we can find angle C for the first triangle e.g.
In the previous LO (10T1.4), students were introduced to calculating the length of unknown sides and the size of unknown angles in non-right-angled triangles.

In Cycle 2, students were not introduced to Greek letters. In Cycle 3, they will have opportunities to use common Greek letters e.g. $\theta, \alpha, \beta, \mu, \sigma$ etc.

Students need to label the triangle with capital letters for the angles and the opposite sides with the corresponding lower case letter as for the previous two LOs (10T1.3 and 10T1.4).

Students need to understand that the Cosine Rule can be used when (including the unknown) you have 3 sides and 1 angle. This can be compared with the Sine Rule from the previous LO.

Students should have the opportunity to see where the area formula is derived from. It is not required for students to reproduce this explanation e.g.

---

In $\triangle ABCD$, using Pythagoras' Theorem:

\[
a^2 = (c - x)^2 + h^2 \\
a^2 = c^2 - 2cx + x^2 + h^2
\]

In $\triangle ACD$, using Pythagoras' Theorem:

\[
b^2 = x^2 + h^2
\]

Substitute $b^2$ into the previous equation:

\[
a^2 = b^2 + c^2 - 2cx
\]

In $\triangle ACD$: $\triangle ACD$

\[
\cos A = \frac{x}{b} \\
x = b \cos A
\]

Substitute $x$ into the previous equation:

\[
a^2 = b^2 + c^2 - 2bc \cos A
\]

---

From the previous explanation, we have:

For finding an angle:

\[
\cos A = \frac{b^2 + c^2 - a^2}{2bc}
\]

For finding a side:

\[
a^2 = b^2 + c^2 - 2bc \cos A
\]
For **Emerging**, students need to calculate the length of an unknown side e.g.

* For Emerging, students need to calculate the length of an unknown side e.g.

Find the length of $x$

Find the length of $x$

**Solution:**

**Step 1:** Label the triangle

$$a^2 = b^2 + c^2 - 2bc \cos A$$

**Step 2:** Choose which form of the formula to use

$$x^2 = 8^2 + 7^2 - 2 \times 8 \times 7 \cos 54^\circ$$

**Step 3:** Substitute the values into the formula

$x^2 = 47.17$

$x = \sqrt{47.17}$

$x = 6.87$ cm

**Step 4:** Solve for $x$

$x$ is quite similar to the values for the other two sides. The triangle is close to an equilateral triangle and so the value for $x$ is reasonable.

**Step 5:** Is the answer reasonable?

For **Developing**, students also need to calculate the size of an unknown angle e.g.

* For Developing, students also need to calculate the size of an unknown angle e.g.

Find the size of angle $\theta$

Find the size of angle $\theta$

**Solution:**

**Step 1:** Label the triangle

$$\cos A = \frac{b^2 + c^2 - a^2}{2bc}$$

**Step 2:** Choose which form of the formula to use

$$\cos \theta = \frac{3.2^2 + 1.4^2 - 2.7^2}{2 \times 3.2 \times 1.4}$$

**Step 3:** Substitute the values into the formula

$\cos \theta = 0.5480$

$\theta = \cos^{-1} 0.5480$

$\theta = 56.8^\circ$

**Step 4:** Solve for $\theta$
Ahmed and Rashid are kayaking in the mangroves. They leave the launch point and paddle in different directions. Ahmed paddles for 80 m and Rashid paddles for 120 m. When they stop, they are 142 m apart. What is the angle ($\alpha$) between the courses of the two kayaks?

**Solution:**

Need to draw the diagram and label the angles and sides.

Choose whether to use the side or angle formula.

Substitute the values and solve for $\alpha$.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\cos A = \frac{b^2 + c^2 - a^2}{2bc}$</td>
<td></td>
</tr>
<tr>
<td>$\cos \alpha = \frac{120^2 + 80^2 - 142^2}{2 \times 120 \times 80}$</td>
<td></td>
</tr>
<tr>
<td>$\alpha = \cos^{-1} 0.033$</td>
<td>$\alpha = 88.1^\circ$</td>
</tr>
</tbody>
</table>

---

**حل:**

تحتاج إلى رسم المثلث وتسوية الأضلاع والزوايا.

اختبر أيهما ستستخدم، معادلة الأضلاع أم معادلة الزوايا.

عوض بالقيم وأوجد قيمة $\alpha$.

<table>
<thead>
<tr>
<th>تحديث</th>
<th>قيمة</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\cos A = \frac{b^2 + c^2 - a^2}{2bc}$</td>
<td></td>
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</tbody>
</table>
This LO allows the students to combine all the different rules they have learnt in a problem solving context. Although students have not used Pythagoras’ Theorem so far in this unit, it may be required during this LO.

Students are **not** told what rules to use in this LO and all problems must include at least one calculation that involves the use of a non-right-angled trigonometric formula.

### For Emerging, students need to be able to identify what rules they need to use to solve the problem.

They may be asked to find an area or to calculate a distance or an angle. It may be helpful to use a flow chart when finding sides and angles e.g.

![Flow chart for finding sides and angles](image)

### For Developing and Mastered, students need to also solve the problem e.g.

A flagpole in the UAE has a point F that is 7 m above level ground. The flagpole is secured from F by two straight wires measuring 13 m and 11 m to two points X and Y on the ground. Angle XZY is 125°.

What is the distance from X to Y?

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**For Emerging**, students need to be able to identify what rules they need to use to solve the problem. They may be asked to find an area or to calculate a distance or an angle. It may be helpful to use a flow chart when finding sides and angles e.g.

- Is the triangle right-angled?
  - Yes
    - Use trig ratios: sin, cos and tan
  - No
    - Do you know a side and its opposite angle?
      - Yes
        - Use Pythagoras’ Theorem
      - No
        - Use the Sine Rule

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Solution:

At the **Emerging** level, students need to recognise that first Pythagoras’ Theorem must be used to find the length of XZ and YZ and then the Cosine Rule needs to be used to find the length of XY.

At the **Developing** level, students use the rules described for Emerging to solve the problem.

At the **Mastered** level, students need to give the answer in the context of the original problem e.g. ‘The distance from X to Y (the ends of the two wires supporting the flagpole) is 17.28 m.’