1. The lengths of the sides of a **right-angled** triangle are all integers.

Prove that if the lengths of the two shortest sides are even, then the length of the third side must also be even.

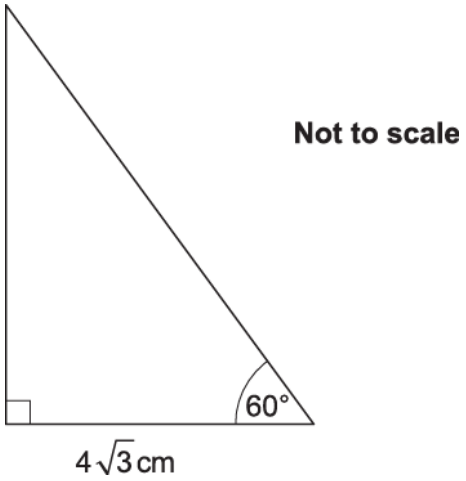
---

[3]

2(a). Write down the exact value of tan 60°.

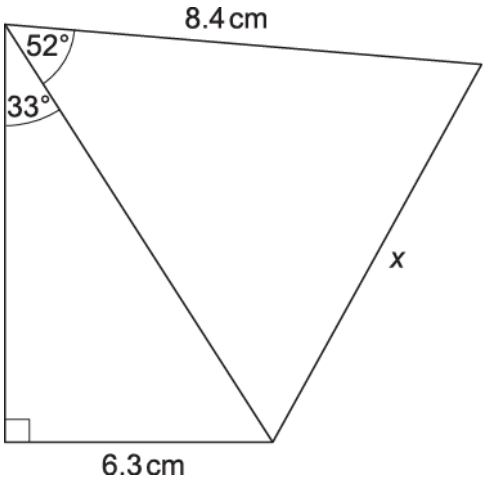
(a) _____ [1]

(b). Find the exact area of this triangle.



(b) _____ cm^2 **[4]**

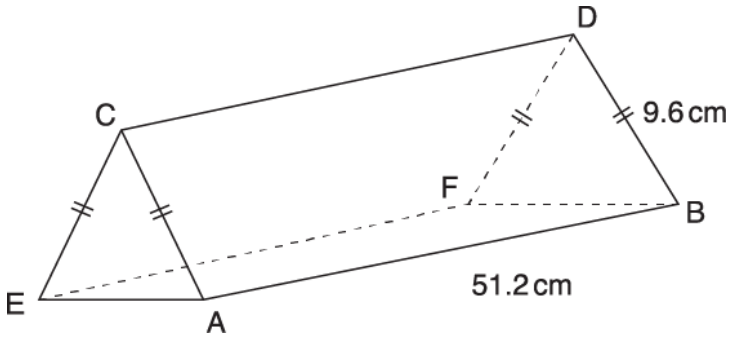
3. Calculate *x*.



Not to scale

_____ cm **[5]**

4. The diagram shows a prism, made from two isosceles triangles and three rectangles.



AC = CE, AB = 51.2 cm and BD = 9.6 cm.

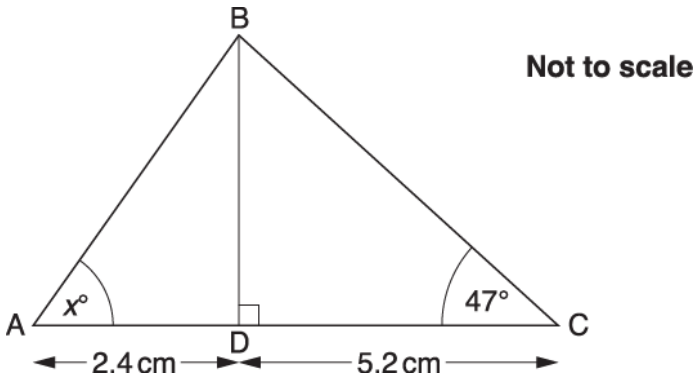
A spider walks from A to the midpoint, M, of CD and then to F.

Calculate the shortest distance that the spider can walk from A to M to F.
Write your answer correct to 3 significant figures.
Show how you worked out your answer.

_____ cm

[5]

5. In triangle ABC, BD is perpendicular to AC.
AD = 2.4 cm, DC = 5.2 cm and angle BCD = 47°.

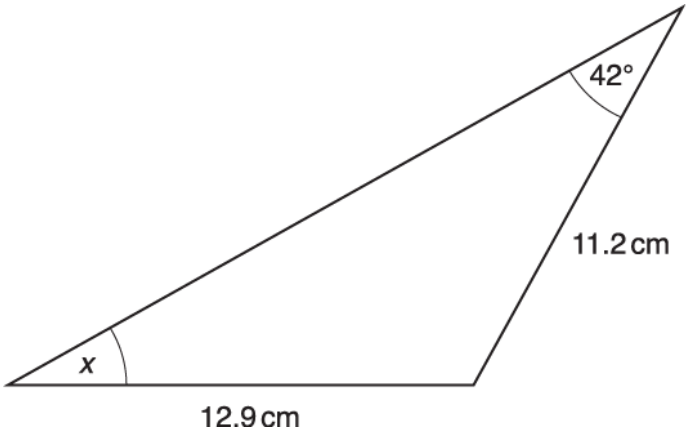


Calculate *x*.

_____ °

[5]

6. Here is a triangle.



Not to scale

Work out the size of angle *x*.

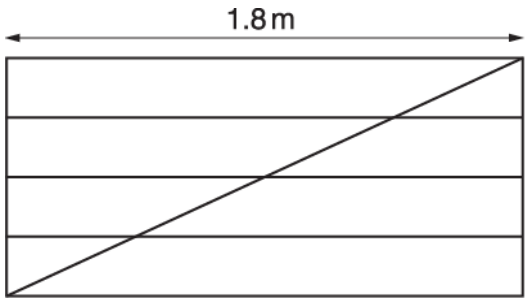
_____ ° **[3]**

7(a). A gate has five horizontal bars and two vertical bars.

It also has one diagonal bar to keep the gate in the shape of a rectangle.

The length of each horizontal and each vertical bar is in the ratio 3 : 2.

The horizontal bars each have length 1.8 m.



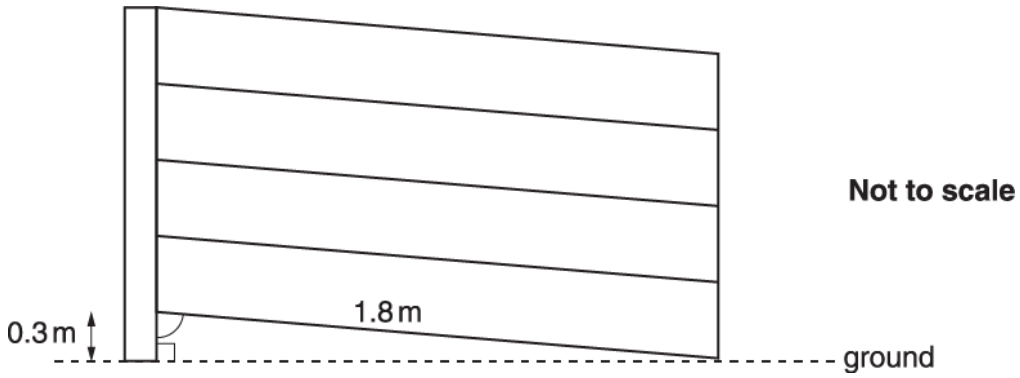
Not to scale

Calculate the total length of the eight bars used to make the gate.

_____ m

[6]

(b). Another gate is made using the same size horizontal and vertical bars but without a diagonal bar.
It is fixed to a gatepost with one end of the bottom bar 0.3 m above the level ground.
It is now no longer a rectangle and is touching the ground at the other end, as shown.

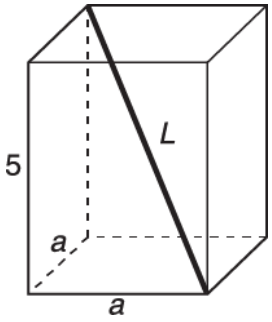


Calculate the angle between the bottom bar and the gatepost.

_____ °

[3]

8. A cuboid of height 5 cm has a square base of side a cm.
The longest diagonal of the cuboid is L cm.



Show that $a = \sqrt{\frac{L^2 - 25}{2}}$.

[4]

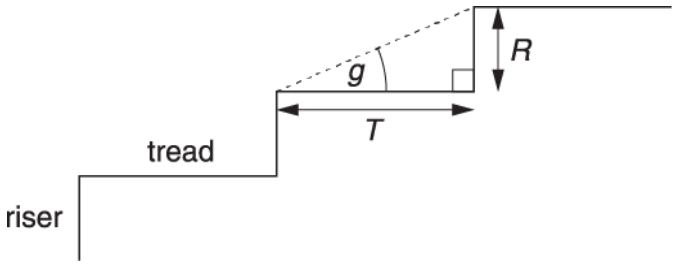
9. Kahli has a sewing box which is a cuboid measuring 15 cm by 35 cm by 10 cm.
She buys a pair of thin knitting needles which are 40 cm long.

Calculate whether a 40 cm knitting needle can fit in her sewing box.
Show how you decide.

[3]

10(a) A staircase consists of treads of length T and risers of length R, as shown.

.



Not to scale

There are four safety requirements:

- T must be at least 220 mm
- R must be at most 220 mm
- $T + 2R$ must be at least 550 mm and at most 700 mm
- angle g must not be more than 42°.

Russell wants a staircase with $T = 222$ mm and $R = 218$ mm.
These values satisfy the first two safety requirements.

Show whether these values satisfy each of the other two safety requirements.

[4]

(b). Calculate the largest value that R can be when $T = 270$ mm. Show that your solution satisfies all the safety requirements.

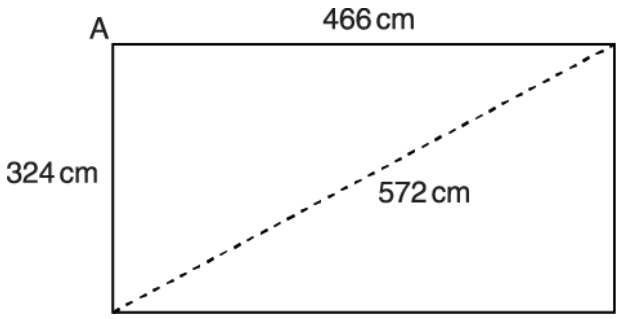
_____ mm **[4]**

11(a). Catherine is designing a new kitchen.

She wants to find out whether the walls meet at an angle of 90°.

She measures two walls and a diagonal across the kitchen floor.

This diagram of the floor shows her measurements.



Not to scale

Use the wall measurements to calculate what the length of the diagonal should be if angle A = 90°.

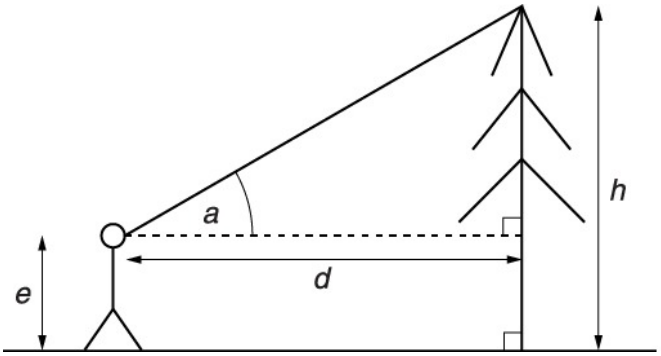
_____ cm **[3]**

(b). Use your result for the length of the diagonal to decide whether angle A is equal to 90°, less than 90° or more than 90°. Show how you decide.

Angle A is _____ 90° because _____

_____ **[1]**

12. Pali wants to find the height, h m, of a tree.
He stands a distance, d m, from the tree.
Then he measures the angle, a, of the top of the tree from the horizontal.
His friend then measures the height, e m, of Pali's eye from the ground.



Not to scale

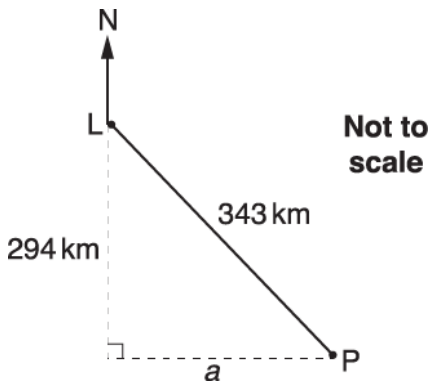
Show that the height of the tree is given by this formula.

$h = e + d \tan a$

[2]

13(a) Paris, P, is 343 km from London, L.

. It is 294 km south of London.



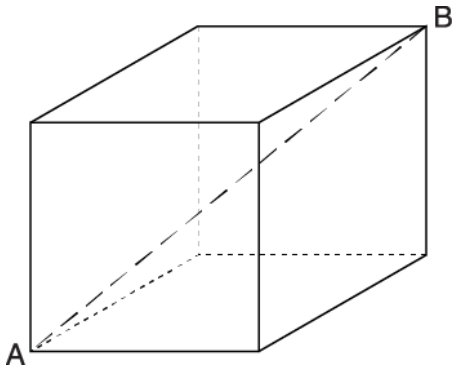
Calculate *a*, the distance that Paris is east of London.

_____ km **[3]**

(b). Calculate the bearing of Paris from London.

_____ ° **[4]**

14. * The diagonal, AB, of this cube has length 9 cm.



Work out the total surface area of the cube.

You may find it useful to call the length of the edges of the cube *x*.

_____ cm^2 **[6]**

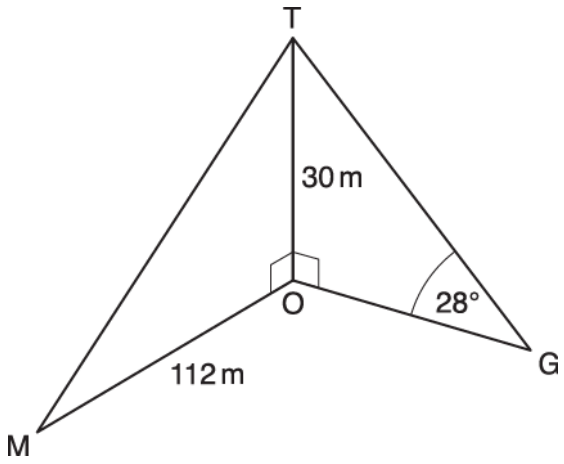
15. A vertical mobile phone mast, OT, is 30 m tall.

The diagram shows two of the straight wires, MT and GT, that support the mast.

M, G and O are all on horizontal ground.

The angle of elevation of the top of the mast, T, from G is 28°.

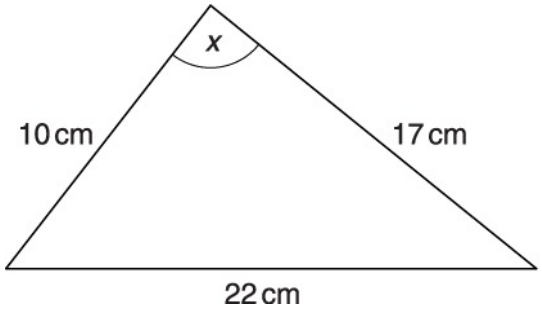
M is 112 m from O.



What **total** length of wire has been used for MT and GT?

_____ m **[6]**

16. Elaine has this triangular piece of material.



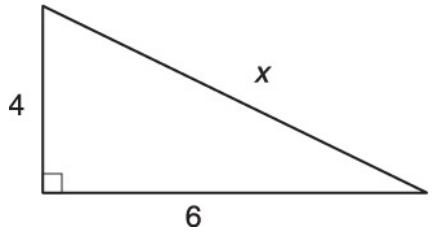
Not to scale

Show that $x = 106°$ correct to the nearest degree.

[3]

17(a) The diagram shows a right-angled triangle.

.

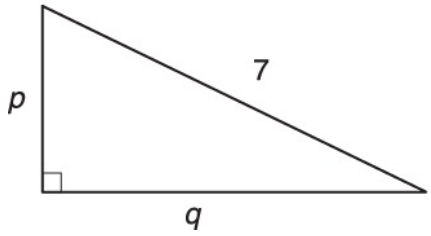


Not to scale

Show that x can be written as $2\sqrt{13}$.

[3]

(b). The diagram shows another right-angled triangle.



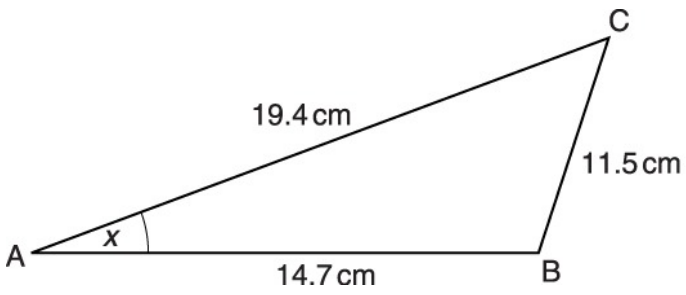
Not to scale

Find **two** different pairs of values for p and q where p is an integer.
Write any surd in its simplest form.

p = _____ and q = _____

p = _____ and q = _____ **[3]**

18. The diagram shows a triangle ABC.
AB = 14.7 cm, BC = 11.5 cm and AC = 19.4 cm.



Not to scale

(i) Show that triangle ABC is **not** a right-angled triangle.

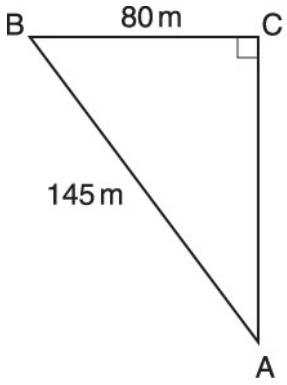
[3]

(ii) Calculate angle *x*.

(ii) _____ ° **[3]**

19(a) The diagram shows a swimming course set out on a lake. Angle BCA = 90°.

.



Not to scale

Swimmers go from A to B to C and then directly back to A.

Calculate the total length of the swimming course.

_____ m **[4]**

(b). C is due north of A.

Calculate the bearing of B from A.

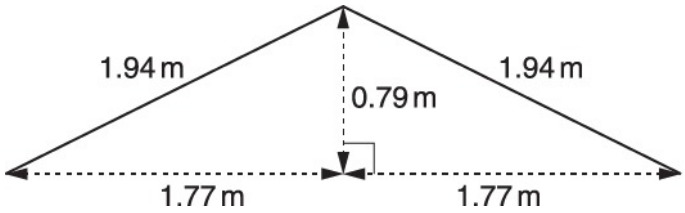
_____ ° **[4]**

20. * The pitch, $x°$, of a roof is the angle between the horizontal and the roof.

The roof of a house is covered with tiles.
The type of tile that can be used depends on the pitch ($x°$) of the roof.
The table below gives information about the range of pitch angles for some types of roof tile.

Type	Plain	Slate appearance	Pantile	Low profile
Roof pitch ($x°$)	x ☐ 35°	x ☐ 25°	x ☐ 22·5°	x ☐ 17·5°

The diagram below shows the end elevation of a roof.



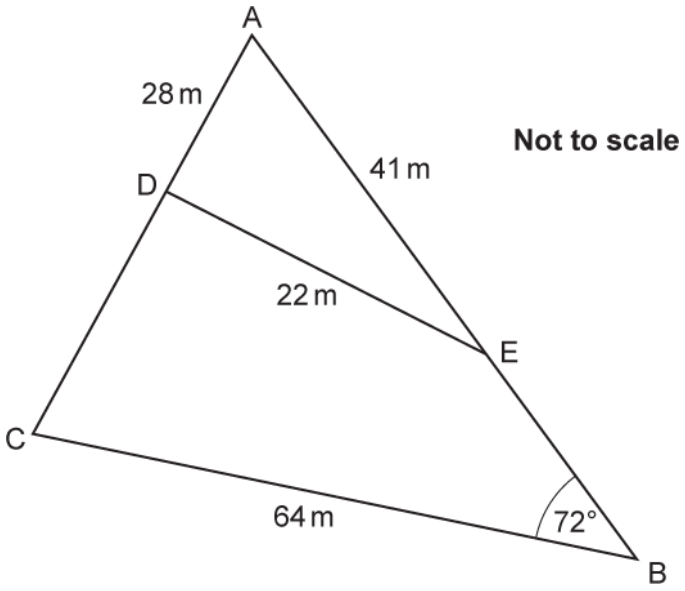
Not to scale

Which of these types of tiles could be used for this roof?

---

[5]

21. The diagram shows triangle ABC with D on AC and E on AB.
DE is a straight line.



AD = 28 m, AE = 41 m, DE = 22 m and BC = 64 m.

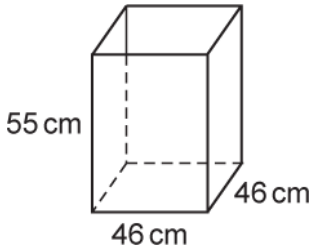
Calculate the length CD.

_____ m **[6]**

22. Alvin has a crate in the shape of a cuboid.

The crate is open at the top.

The internal dimensions of the crate are 46 cm long by 46 cm wide by 55 cm high.



Alvin has a stick of length 95 cm.

Alvin places the stick in the crate so that the shortest possible length extends out above the top of the crate.

Calculate the length of the stick that extends out of the crate.

_____ cm **[4]**

23(a) The angles in a triangle are in the ratio 1 : 2 : 3.

.

Show that the triangle is a right-angled triangle. **[2]**

(b). The hypotenuse of the triangle is 15 cm long.

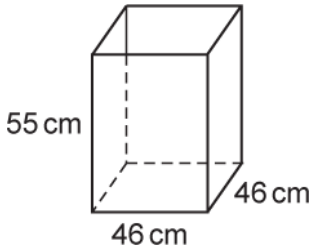
Calculate the length of the shortest side in the triangle.

---------- cm **[4]**

24. Alvin has a crate in the shape of a cuboid.

The crate is open at the top.

The internal dimensions of the crate are 46 cm long by 46 cm wide by 55 cm high.



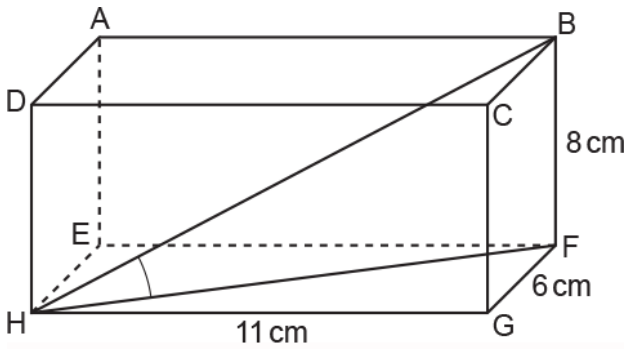
Alvin has a stick of length 95 cm.

Alvin places the stick in the crate so that the shortest possible length extends out above the top of the crate.

Calculate the angle the stick makes with the base of the crate.

_____ ° **[3]**

25. The diagram shows a cuboid ABCDEFGH.

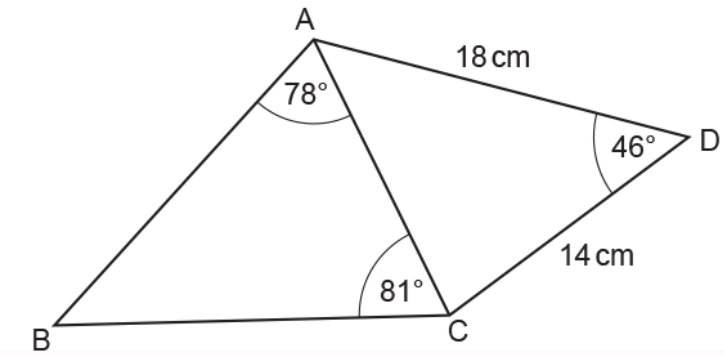


Calculate angle BHF.

---------- ° [5]

26(a) ABC and ACD are triangles.

.



Not to scale

Show that AC = 13.0 cm, correct to 3 significant figures. **[4]**

(b). Calculate BC.

---------- cm **[3]**

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Part marks and guidance	
1			e.g. $a^2 + b^2 = c^2$ $a = 2x$ and $b = 2y$ implies $c^2 = 4x^2 + 4y^2$ So c is even	3	**B1** for use of Pythagoras' theorem **M1** for even × even = even **soi**	
			Total	3		
2	a		$\sqrt{3}$	1		
	b		$24\sqrt{3}$	4	**M1*** for $\frac{\text{height}}{4\sqrt{3}} = \textit{their}\ \tan 60°$ **A1** for 12 or $4\sqrt{3} \times \sqrt{3}$ ***M1 Dep** for $\frac{1}{2} \times 4\sqrt{3} \times$ *their* '12'	
			Total	5		
3			9.2(0)	5	**M1** for $\frac{6.3}{\sin 33}$ **A1** for 11.567(…) **soi** **M1 dep** *for evidence of cosine rule used **M1** for *their* '11.6'^{2} + 8.4^2 – 2 × *their* '11.6' × 8.4 × cos 52	**rot** to 3 or more sf *Dep on 1st M1 84.7(…) seen implies 4
			Total	5		

Question			Answer/Indicative content	Marks	Part marks and guidance	
4			54.7	5	**M2** for $\sqrt{their\,(51.2\div 2)^2+9.6^2}$ or 27.3[4...] or **M1** for (*their* 51.2÷2)^2 + 9.6^2 or 747.52 and **M1** for *their* 27.3[4...] × 2 **A1** for 54.68[...] Note: 54.68[...] scores **4** marks If **0** scored then award **SC1** for a Pythagorean statement e.g. $\sqrt{a^2+b^2}$ where *a* and *b* are numbers. If **A0** then **SC1** for their answer to more than 3 sf correctly rounded to 3 sf.	Alt. method: **M3** for $\sqrt{51.2^2+19.2^2}$ or **M2** for '*their correct Pythagoras' statement*' $\sqrt{51.2^2+their\,(9.6\times 2)^2}$ or **M1** for '*their correct partial Pythagoras' statement*' eg 51.2^2 + (*their* 9.6×2)^2 **A1** for 54.68[...] Examiner's Comments Many never used Pythagoras' Theorem but simply added lengths of edges giving an incorrect answer of 70.4. Another common incorrect answer was 44.8 where candidates incorrectly assumed the distance MF was 9.6 and then added this to AC (9.6) and then to CM (25.6).
			Total	5		

Question			Answer/Indicative content	Marks	Part marks and guidance	
5			66.65 – 66.81 or 67	5	**M2** for 5.2 × tan 47 or 5.57[...] or 5.58 oe or **M1** for tan 47 = [ ] ÷ 5.2 oe and **M2** for $\tan^{-1}$ ('*their* 5.57' ÷ 2.4) oe or **M1** for tan [*x*] = *their* 5.57 ÷ 2.4 oe	Accept any correct method e.g. sin rule i.e. $\tan^{-1}$(2.323....). <u>Examiner's Comments</u> This question was either answered very well or very poorly. Often the only attempt was to give an answer of 43 from using ABD as 47°. Rather than use the tangent twice there were many who tried to use sine rule or just sine or cosine with Pythagoras' Theorem. Some of these longer methods had figures all over the paper and were difficult to follow. Even if the method was correct and easy to follow, the answer often fell outside the acceptable range because there were too many approximations and truncations.
			Total	5		
6			35.5 to 36	3	**M2** for $\frac{11.2\times\sin 42}{12.9}$ soi by 0.5809... **Or M1** for $\frac{\sin x}{11.2} = \frac{\sin 42}{12.9}$ oe	<u>Examiner's Comments</u> There were some excellent sine rule solutions to this question although some candidates struggled with the transformation of the formula after a correct substitution. Less able candidates assumed the triangle to be right-angled and used Pythagoras' theorem and/or trigonometry.
			Total	3		

Question			Answer/Indicative content	Marks	Part marks and guidance	
7	a		Vertical bar = 1.2 m	2	**M1** for $\frac{2}{3} \times 1.8$ oe	NB may be on diagram
			Diagonal bar = 2.16(3…) or 2.2 nfww	3	**and M2** for $\sqrt{1.8^2 + their 1.2^2}$ or **M1** for 1.8^2 + *their* 1.2^2 or 4.68	allow their FT length of diagonal to imply the square root 1.8^2 + *their* 1.2^2 ofseen evaluated;
			Total 13.5 to 13.6 nfww	1		eg allow M2 for 1.9(386) after $1.8^2 + 0.72^2 = 3.7584$ <u>Examiner's Comments</u> Candidates coped well in this AO3 question with the unsignposted Pythagoras' theorem, with most realising that they needed to apply it for the diagonal bar. However, there were many errors in obtaining the height of the vertical bars, with a wrong use of the ratio 3 : 2 leading to dividing 1.8 by 5 instead of 3 a common error. However, a number of candidates gained all 6 marks on this question.
	b		$\cos\theta = \frac{0.3}{1.8}$	M1	or for complete method correct using Pythag (adj = 1.7748..) and another trig ratio	0 for scale drawing
			Inv trig fn seen or used	M1	Not dep on first M1	may be implied by answer

Question			Answer/Indicative content	Marks	Part marks and guidance	
			80.2 to 80.8	A1	accept 80 or 81 after correct trig seen; allow **B3** for 80.2 to 80.8 nfww	<u>Examiner's Comments</u> Compared with previous inverse trigonometry questions, this was answered very well, with many correct responses and good notation. There were a few instances of the cosine rule and some candidates were determined to perform a sine inverse via first using Pythagoras to find the missing side – although the side was usually correct, premature rounding sometimes caused a lack of accuracy in the angle.
			Total	9		

Question			Answer/Indicative content	Marks	Part marks and guidance	
8			$L^2 = 5^2 + a^2 + a^2$	M2	may be in root form; for clear correct 3D Pythagoras statement – may be in two stages;	
					or allow **M1** for $L^2 = 52 + d^2$ oe, and **M1** for $d^2 = a^2 + a^2$, where d is the diagonal of the base (accept the square roots of these statements)	or similarly may use the diagonal of a vertical face
					allow **only M1** for $L^2 = 5^2 + 2a^2$ with no prior stage or for a correct 3D Pythag statement such as 'when $a = 3$, $L^2 = 5^2 + 3^2 + 3^2$'	working backwards: allow M1 for rearranging given answer to $2a^2 = L^2 - 25$ with at least one intermediate step and
			$2a^2 = L^2 - 25$	M1	no FT from wrong statements or with a number subst for a	M1 for reaching $L^2 = 5^2 + 2a^2$ or $L^2 = 25 + 2a^2$ and M2 for full
			showing $a = \sqrt{\frac{L^2 - 25}{2}}$	M1	for rearrangement to $2a^2$ as subject	justification of why $L^2 = 25 + 2a^2$ oe using Pythagoras

Question			Answer/Indicative content	Marks	Part marks and guidance	
					for completion to given answer showing at least one correct intermediate stage; NB square root symbol must extend below fraction line ; LHS may be in words	ignore extra work (may have errors) outside their main argument <u>Examiner's Comments</u> Many candidates found this proof difficult. Some were able to write down a correct 3D Pythagoras equation and rearrange this successfully. Others worked in two stages, finding the diagonal of the base and using this to find *L*. This method was less successful. The main difficulty was in squaring $\sqrt{2a^2}$. Others rearranged the answer to make L^2 the subject but could go no further. $L^2 = a^2 + 5^2$ was a common error. Many less able candidates merely attempted to substitute a number into the Pythagoras formula, or omitted this question.
			Total	4		

Question			Answer/Indicative content	Marks	Part marks and guidance	
9			$\sqrt{15^2+35^2+10^2}$	M2	**M1** for $15^2 + 35^2 + 10^2$ or 1550 (may be in two steps of 2D Pythagoras)	If in two steps then figures are: 15, 35 pair = 1450 sq rt = 38.0788.. 15, 10 pair = 325 sq rt = 18.0277… 35, 10 pair = 1325 sq rt = 36.4005.. (roots may be rot to 3sf or more) + must combine to earn **M2** or **M1**
			39.3 to 39.4 and no	A1	Ignore additional comments Allow 39 only after $\sqrt{15^2+35^2+10^2}$ or $\sqrt{1550}$ is shown with no premature approximation Allow **B3** for 39.3 to 39.4 nfww and no **Examiner's Comments** Good candidates answered this well, although a few came to the wrong conclusion. Merely attempting 2-D Pythagoras was the usual error. Weak candidates often found the volume.	ie **M0** for just 2D Pythagoras
			Total	3		

Question			Answer/Indicative content	Marks	Part marks and guidance	
10	a		$T + 2R = 658$ [so OK]	B1	Or may use one of given values to find limits for the other	Using $T = 222$, $164 \leq R \leq 239$ Using $R = 218$, $114 \leq T \leq 264$
			$\tan g = \frac{R}{T}$ or $\frac{218}{222}$	M1	Condone poor notation	May find hypotenuse = 311.(1…) and then use sin or cos
			Inverse trig fn seen or used	M1	FT *their* trig statement even if sin or cos used; may be implied by answer	If using sine rule, need to get to $\sin g = \frac{218 \times \sin 90}{311(.1...)}$ for **M1**, and a
			44 or 44.4 to 44.5 [so doesn't satisfy]	A1	**A0** if say 'does satisfy' oe or: **M2** for $R = 222 \times \tan 42$ or $T = \frac{218}{\tan 42}$ Or **M1** for $\tan 42 = \frac{R}{222}$ or $\tan 42 = \frac{218}{T}$ **A1** for $R = 199.8$–200 so no or for $T = 242(.1…)$ so no (may be as inequalities but not required) If M0, allow **SC1** for scale drawing finding angle as 44 to 45·[and 'so No']	similar stage for use of cos rule

Question			Answer/Indicative content	Marks	Part marks and guidance	
	b		Valid checking of all conditions and final conclusion max $R = 215$	4	Condone omission of explicitly checking conditions *'T* must be at least 220 mm' and *'R* must be at most 220 mm'	
					M1 for [R =] 270 tan 42 or $\tan 42 = \frac{R}{270}$	May find hyp and use sin or cos but need to go on to have used T and R
					or correct trig statement using T = 270 and R = 215 or 220	
					M1 for $2R + 270 = 700$ seen or used	eg **M1** for $2R$ = [280 to] 430 accept inequalities
					Allow **A1** for one of [R =] 243(. 1…) or R = 215 or g = 38.5…	These values will imply the relevant **M1** if not already earned;
					Or allow **M1A1** for $2R + T$ oe = 710 from using R = 220 and T = 270	allow **M1A1** for 2 × 215 + 270 = 700, allow amongst other trials if identified as correct
					Examiner's Comments Many candidates made good attempts at this AO3 question, particularly part (a). Many obtained 658, with a few others making an arithmetic error in their working. There was good use of trigonometry with many correct angles found. Some candidates used Pythagoras' theorem to find the hypotenuse and then $\sin^{-1}$ or $\cos^{-1}$ and often did so correctly. In part (b), fewer gained full marks by showing all the conditions were met by their solution, but many and managed to set-up and solve $2R + 270 = 700$.	**M0** for just trials with other values of R; **M0** for scale drawing instead of trig (but may earn other M1)

Question			Answer/Indicative content	Marks	Part marks and guidance	
			Total	8		
11	a		567.5 to 567.6 or 568 or 570	3	nfww **M2** for $\sqrt{466^2 + 324^2}$ oe or equivalent complete method using trig (condone poor notation) Or **M1** for $466^2 \pm 324^2$ or for 322 132 or any attempt at Pythagoras (eg 217 156 + 104 976) <u>Examiner's Comments</u> Most candidates made a good attempt at Pythagoras' theorem, with many gaining full marks. Some confused attempts at trigonometry were seen, but none concluded successfully.	570 from scale drawing scores **0**
	b		More than 90 since diagonal should be less than 572 oe	1FT	FT only if at least **M1** gained in (a) <u>Examiner's Comments</u> The comment was found more difficult and was sometimes omitted. However some very good explanations were seen which clearly demonstrated their appreciation of why the angle was more then 90°.	
			Total	4		

Question			Answer/Indicative content	Marks	Part marks and guidance	
12			Height of triangle = $h - e$ oe	1	May be on diagram	eg y shown on diagram and $h = y + e$ used
			Tan $a = \frac{h-e}{d}$ or $h - e = d \times \tan a$	1	If **0** in question, allow **SC1** for clear attempt to use tan a = opp/adj with adj = d even if opp = h Examiner's Comments The explanations were generally poor. However, some clear correct statements involving 'tan' were seen, and some correctly showed that $h = e$ + the opposite side of the triangle, often sensibly using a diagram.	
			Total	2		

Question			Answer/Indicative content	Marks	Part marks and guidance	
13	a		$a^2 + 294^2 = 343^2$	M1	oe; for correct Pythagoras statement	allow M1 for $a^2 = 31213$
			$\sqrt{343^2 \pm 294^2}$	M1		
			176.6 to 177	A1	or **B3** nfww; allow **A1** for 180 if correct method seen **Examiner's Comments** Most candidates realised that they needed to use Pythagoras' Theorem in the first part and many did so competently.	
	b		e.g. $\cos PLS = \frac{294}{343}$	M1	for a correct trig statement with clearly identified angle; may find either angle in the triangle	Condone poor notation [S here is 3rd vertex of triangle; candidates will use other refs, e.g. o, a and h marked on the triangle.]
			use of inverse trig function	M1	allow even if wrong trig function used	if e.g. 31 appears with no identification, allow this to imply the second M1
			bearing = 148.9 to 149.1	A2	A1 for LPS = 58.9 to 59.1 or for PLS = 30.9 to 31.1 **Examiner's Comments** Whilst measuring the bearing or assuming a 45° angle was common amongst the weaker candidates, most others included some reasonable trigonometry. Obtaining 31° or 59° was frequently seen, although some did not always make it clear which angle they were finding. After succeeding with the hard trigonometry work, determining the correct bearing was a stage too far for many.	allow 148.0 to 149.1 to imply the correct angle used
			Total	7		

Question			Answer/Indicative content	Marks	Part marks and guidance	
14			* Answer of 161.99 to 162.24 with correct and clear method shown. Appropriate language throughout.	6	$x^2 + x^2 + x^2 = 9^2$ $3x^2 = 81$ $x^2 = 27$ $(x = \sqrt{27})$ $SA = 6x^2 = 162$ (Allow 161.99 to 162.24)	For Pythagoras: – a, b and c must be a number or a letter (one of which may be a, b or c) - allow cosine rule with angle 90
			Correct answer and method shown but with less structure to solution and slips in notation	5-4	Attempt to use 3D Pythagoras (could be using 2D twice) **and** attempt to find total surface area	
			Any attempt at Pythagoras in 3D **Or** correct use of Pythagoras in 2D **and** considers total surface area	3-2	Any attempt at Pythagoras in 3D **Or** any attempt at Pythagoras in 2D **and** considers total surface area	For **3** or more marks Pythag. must contain x

Question			Answer/Indicative content	Marks	Part marks and guidance	
			Any attempt at Pythagoras in 2D **or** attempt to find total surface area	1-0	No relevant comment **Examiner's Comments** This was the QWC question for this paper. This requires candidates to present their work in a logical, coherent fashion and a small number were able to. Disappointingly, there were those who correctly found the length of a side of the cube but then found its volume instead of the surface area. Of the rest, most realised they needed to use Pythagoras' theorem but many got confused if they followed a 2-D method rather than a 3-D method. A trial and improvement method was seen on a number of occasions, often leading to a correct answer. It was common to see candidates assuming that AB was the diagonal of a square. Though an incorrect start, many went on to find a value for the length of the side of the cube and then the total surface area. Weaker candidates struggled to present correctly any correct form of Pythagoras' theorem.	For **2** or **1** marks Pythag. may be using values or letters and a value
			Total	6		

Question			Answer/Indicative content	Marks	Part marks and guidance	
15			179.8 to 180 with commentary (may be using letters)	6	e.g. : TG = 30/sin28 = 63.9 to 64 : TM = $\sqrt{(112^2 + 30^2)}$ =115.9 to 116 *Allow fully correct alternative methods for TG and TM*	
			179.8 to 180 with no commentary	5-4	30/sin28 soi **and** $\sqrt{(112^2 + 30^2)}$ soi	
			30/sin28 soi OR $\sqrt{(112^2 + 30^2)}$ soi OR sin 28 = 30/× **and** $112^2 + 30^2$ soi	3-2	sin 28 = 30/× OR $112^2 + 30^2$ soi	

Question			Answer/Indicative content	Marks	Part marks and guidance	
			sin identified as the trig ratio required for TG oe OR some use of Pythagoras for TM oe	1-0	No worthy work Examiner's Comments A lot of candidates set their work out clearly, with appropriate commentary and scored full marks. Others spoiled their answers by not indicating which length(s) they were finding. In a QWC question more effort is needed to communicate the method being used and what is being found. Most used Pythagoras to calculate TM and, impressively, a good number found TG from sin $\frac{30}{\sin 28}$ Some calculated TG by first finding OG and then using Pythagoras in triangle TOG. Errors occurred when candidates rearranged a trig. formula incorrectly or confused lengths and angles and used them inappropriately in a formula.	
			Total	6		

Question			Answer/Indicative content	Marks	Part marks and guidance	
16			106.225…rot to at least 1dp	3	*Mark best attempt* M2 for $\frac{10^2+17^2-22^2}{2\times10\times17}$ oe Or M1 for $22^2 = 10^2+17^2-2 \times 10 \times 17 \times \cos x$ oe Examiner's Comments It was clear that many candidates did not understand the instruction to 'Show that…'. Often they used 106° in the cosine rule formula to show that the opposite side was 22 cm. Some did understand, quoted the cosine rule formula with cos *x* as the subject, substituted the lengths and arrived at a value for the angle, given to at least one decimal place. Those using the cosine rule formula from the formula sheet usually substituted lengths correctly but then failed to rearrange their equation appropriately.	M2 soi by –0.2794117647 rot Or –95/340
			Total	3		

Question			Answer/Indicative content	Marks	Part marks and guidance	
17	a		$4^2 + 6^2$ or better	1	soi by 52	
			$\sqrt{52}$	1	soi by $\sqrt{4 \times 13}$ or $\sqrt{4} \times \sqrt{13}$	
			$\sqrt{4 \times 13}$ or $\sqrt{4} \times \sqrt{13}$ [= $2\sqrt{13}$]	1	accept $\sqrt{2} \times \sqrt{2} \times \sqrt{13}$ **Examiner's Comments** Most candidates recognised that they needed to use Pythagoras' Theorem and gave the correct equation, although a few tried to multiply rather than add while some failed to square the values correctly. The majority reached $\sqrt{52}$ but many could go no further or simply wrote $\sqrt{52} = 2\sqrt{13}$. Successful candidates reduced $\sqrt{52}$ into $\sqrt{2 \times 2 \times 13}$ or more frequently $\sqrt{4 \times 13}$ and a few lost out by writing $\sqrt{2 \times 26}$.	

Question			Answer/Indicative content	Marks	Part marks and guidance	
	b		any two from p 1 2 3 4 5 6 q $4\sqrt{3}$ $3\sqrt{5}$ $2\sqrt{10}$ $\sqrt{33}$ $2\sqrt{6}$ $\sqrt{13}$	3	**B2** for one fully correct solution or for two correct solutions not fully simplified or **B1** for one correct solution not fully simplified If **0** scored **SC2** for both answers correctly simplified and reversed or **SC1** for one correctly simplified answer reversed <u>Examiner's Comments</u> Most used the correct equation of $p^2 + q^2 = 7^2$ but few candidates understood the principle behind the question and frequently attempted using 'trial and improvement' with little apparent consideration of the outcomes achieved. Some failed by using integer values above 6 and others gave two pairs of integers or decimals. Others did not appreciate what an integer was and gave surds for both p and q. Unsimplified surds were fairly common but fortune smiled on those who selected 4 with $\sqrt{33}$ or 6 with $\sqrt{13}$ as they did not need to be simplified.	Unsimplified versions p 1 2 3 4 5 6 q $\sqrt{48}$ $\sqrt{45}$ $\sqrt{40}$ $\sqrt{33}$ $\sqrt{24}$ $\sqrt{13}$ or $2\sqrt{12}$ condone reduction to roots of prime numbers eg $\sqrt{33}=\sqrt{3}\sqrt{11}$ isw after correct unsimplified versions seen for max **B2**
			Total	6		

Question			Answer/Indicative content	Marks	Part marks and guidance	
18		i	full correct argument e.g. $14.7^2 + 11.5^2$ [=] 19.4^2 348.34 ≠ 376.36 use of appropriate symbol (≠) or a statement that these two numbers are not the same	3	**M1** for an appropriate method e.g. $\sqrt{19.4^2 - 11.5^2}$, $\sqrt{19.4^2 - 14.7^2}$, $\sqrt{11.5^2 + 14.7^2}$ **oe** or cosine rule for angle B **A1** for correct result to compare e.g. 15.6..., 12.6..., 18.6... or 18.7 or B = 94.7 **A1** for a statement that the result does not equal the actual figure <u>Examiner's Comments</u> In (i) it was intended that Pythagoras' theorem should be used, however in using trigonometry the question was made more difficult. There were some good calculations, but they need to show either AC has to be shorter or that angle B is not 90°. Other approaches rarely resulted in success.	accept any correct method including a drawing tolerance ±2 mm, **M1** for a triangle with one side correct **A1** for all three sides correct **A1** for measuring *their* angle accurately (±2°) or stating clearly it is not 90° e.g. another equivalent method would be $11.5^2 + 14.7^2 = 18.6...^2$ for **M1 A1** allow these results rounded

Question			Answer/Indicative content	Marks	Part marks and guidance	
		ii	36.2 to 36.22 or 36	3	**M2** for (cos *a*) = $\frac{19.4^2+14.7^2-11.5^2}{2\times19.4\times14.7}$ or 0.8068(...) or **M1** for $11.5^2 = 19.4^2 + 14.7^2 - 2 \times 19.4 \times 14.7 \times \cos$ *(their a)* Examiner's Comments In (ii) the only method was the cosine rule, but many used incorrect results from part (i) with the sine rule. Some tried to use trigonometry, applicable only to right-angled triangles and they should know that these methods are not valid for this type of triangle.	Make sure that 36 does not come from a wrong method
			Total	6		

Question			Answer/Indicative content	Marks	Part marks and guidance	
19	a		345.9[3…] or 346	4	**B3** for 120.9[3…] or 121 as answer OR **M2** for $\sqrt{145^2 - 80^2}$ or $\sqrt{14625}$ Or **M1** for $145^2 = 80^2 + AC^2$ or better AND **M1** for 145 + 80 + *their* '120.9' **Examiner's Comments** Most candidates identified that this part required the application of Pythagoras' Theorem with many completely correct answers seen. Some candidates correctly found the length AC, but then lost the final mark because they did not add the sides to find the total length. A significant number of candidates used Pythagoras and added the squares rather than subtracting so could only gain a final method mark for finding the perimeter using their lengths: the diagram should have been a clue that AC should be shorter than AB. Very few candidates attempted to use trigonometry, usually unsuccessfully, as a route to finding AC.	Allow any number for 120.9 unless contradicted by their AC

Question			Answer/Indicative content	Marks	Part marks and guidance	
	b		326.5 to 326.6 or 327	4	**B3** for 33.4 to 33.5 or 33 OR **M2** for $\sin^{-1}(80/145)$ or $\cos^{-1}$(*their* 120.9/145) or $\tan^{-1}(80/$*their* 120.9) Or **M1** for sin […] = 80/145 or cos […] = (*their* 120.9/145) or tan […] = (80/*their* 120.9) Or **B1** for 56.5 to 56.6 seen AND **M1** for 360 – *their* BAC correctly evaluated **Examiner's Comments** This part was very poorly done with few candidates identifying the need to use trigonometry. Many candidates measured an angle from the diagram to find the bearing, even though 'not to scale' was stated and the question asked for a calculation. Candidates should have noted the allocation of four marks to this question and realised that measuring an angle could not be the correct approach. Those candidates who did use a trigonometric ratio often reached the correct value for angle BAC and gained three marks, with some then correctly using that angle to find the bearing. It was sometimes unclear from working whether candidates were applying a trigonometric ratio incorrectly or whether they were finding an incorrect	Allow 3 marks for answer 326 with no working Or M1 for any correct statement of sine or cosine rule with values correctly substituted and M2 for correct $\sin^{-1}$ or $\cos^{-1}$ statement following from this *Their* BAC must be clearly identified, may be seen on diagram or be **any** angle found using trig

Question			Answer/Indicative content	Marks	Part marks and guidance	
					angle. Some candidates used the sine rule, often correctly, or the cosine rule, usually incorrectly.	
			Total	8		

Question			Answer/Indicative content	Marks	Part marks and guidance	
20			* Fully correct and clear method to find pitch angle of roof leading to identification of Pantile and Low Profile tiles. Clear correct calculations using correct trig statements Angle calculated must be identified as pitch angle or *x* and must be correct and given to at least 2sf	5	eg pitch angle = $\tan^{-1}\left(\frac{0.79}{1.77}\right)$ = 24.1° or 24.05[…]° Pantile and low profile tiles suitable for this angle Alternative methods: $\sin^{-1}\left(\frac{0.79}{1.94}\right)$ = 24.0[3…]° or $\cos^{-1}\left(\frac{1.77}{1.94}\right)$ = 24.2° or 24.16[…]°	
			Pantile and low profile tiles identified with correct angle seen, working not clearly set out and / or angle not identified as pitch OR Correct pitch angle found with clear correct calculations but no / incorrect identification of tiles OR Clear correct calculations with method with max one error leading to correct choice of tiles for *their* angle	4-3	Correct angle found with no / incorrect identification of tiles and working not clearly set out OR Correct inverse trig statement seen $\tan^{-1}\left(\frac{0.79}{1.77}\right)$ or $\sin^{-1}\left(\frac{0.79}{1.94}\right)$ or $\cos^{-1}\left(\frac{1.77}{1.94}\right)$	

Question	Answer/Indicative content	Marks	Part marks and guidance
	Correct trig statement for x or *their* identified angle seen $\tan = \frac{0.79}{1.77}$ or $\sin = \frac{0.79}{1.94}$ or $\cos = \frac{1.77}{1.94}$ OR Attempt at scale drawing with reasonable scale identified OR Attempt to use trigonometry or scale drawing **and** correct choice of tiles for their angle	2-1	Attempt to use trigonometry or attempt at scale drawing eg incorrect statement using trigonometry and at least one of 1.94, 1.77 or 0.79 OR Correct choice of tiles for *their* stated angle
	Allow equivalent marks for use of sine rule or cosine rule: eg $\sin^{-1}\left(\frac{0.79\sin 90}{1.94}\right) = 24.0[3\ldots]$ or $\cos^{-1}\left(\frac{1.94^2 + 1.77^2 - 0.79^2}{2\times 1.94\times 1.77}\right) = 24.0[3\ldots]$ Allow equivalent marks for reverse calculations using pitch angles, for full marks both slate and pantiles must be considered: Eg Min height for each tile, must be compared with 0.79: plain = 1.77 tan 35 = 1.23, slate = 1.77 tan 25 = 0.825, pantile = 1.77 tan 22.5 = 0.733, low profile = 1.77 tan 17.5 = 0.558		**Examiner's Comments** Many candidates were able to use trigonometry correctly to calculate the angle of the roof and then use the given information to identify the correct types of tiles. As this was a quality of written communication question, in order to gain full credit, working had to be mathematically correct and clearly laid out with the calculations clearly identifying the angle being found, together with a clear conclusion identifying the appropriate tiles. There were a number of reasons for one mark being lost after reaching the correct angle: failing to identify the angle calculated as the pitch angle, selecting just pantiles, misunderstanding the inequalities and hence selecting slate and plain or not setting out the calculations in a mathematically correct way. Candidates were expected

Question			Answer/Indicative content	Marks	Part marks and guidance	
					to show sufficient accuracy in their calculations and indicate clearly what values they were using, so expressions such as $\sin^{-1}$(ans) were not acceptable for full credit. Candidates generally coped with being given more information than was required although some did use all three trigonometric ratios rather than just one. The majority of candidate used right-angled trigonometry although sine and cosine rule were also seen. Some candidates who used the cosine rule were unable to rearrange it correctly to find cos *A*. A small number of candidates used a reverse method and found the height of the roof or the length of the slope using the angle given for each type of tile, though they were then often confused about what to do with the values they had calculated.	
			Total	5		

Question			Answer/Indicative content	Marks	Part marks and guidance		
21			92 or 92.28 to 92.6	6	**M3** for correct explicit cos rule to find angle A in ADE with cos as subject. $[\cos A =] \frac{28^2 + 41^2 - 22^2}{2 \times 28 \times 41}$ oe soi or **M2** for correct implicit form of the cos rule to find angle A $22^2 = 28^2 + 41^2 - 2 \times 28 \times 41 \times \cos A$ or **M1** for either of the above forms with only one error AND **M2** for correct sine rule e.g. $\frac{64 \times \sin 72}{\sin their A}$ oe soi or **M1** for $\frac{64}{\sin their A} = \frac{[...]}{\sin 72}$ oe if **0** scored **SC1** for explicit form of cos rule to find angle D or E in	accept any correct method implied by [A=] 30.3 to 30.4	

Question			Answer/Indicative content	Marks	Part marks and guidance	
					ADE e.g. $[\cos D =] \frac{28^2 + 22^2 - 41^2}{2 \times 28 \times 22}$ **Examiner's Comments** This question was found to be difficult and many candidates could not get started. Three assumptions were commonly made by a large number of the candidates; firstly, that triangles ADE and ACB were similar leading to the ratio 2.9 being used to find AC; secondly, angle ADE was a right angle leading to a whole series of different possibilities for angle DAE, such as 46.92°, 32.45° or 38.16°, but these were seldom used in the sine rule to find AC; thirdly, that DE was parallel to CB making angle AED 72°. Those candidates who realised they needed to use the cosine rule to find angle DAE fell into two groups: those who correctly substituted the lengths of the triangle ADE and were then able to complete the problem with some success (although some lost accuracy by approximating the angle to 30°) and those who either used the implicit form of the rule and couldn't rearrange it successfully or ended up finding angle ADE.	

Question			Answer/Indicative content	Marks	Part marks and guidance		
			Total	6			
22			9.8[1…]nfww	4 1 AO1.3b 2 AO3.1d 1 AO3.3	M3 for $\sqrt{46^2+46^2+55^2}$ or 85.18 to 85.2 or $\sqrt{7257}$ OR M2 for $46^2 + 46^2 + 55^2$ or 7257 or $\sqrt{46^2+46^2}$ or $\sqrt{4232}$ or 65.05 to 65.1 or $\sqrt{46^2+55^2}$ or $\sqrt{5141}$ or 71.7[...] OR M1 for $46^2 + 46^2$ or 4232 or $46^2 + 55^2$ or 5141	Accept answers rounding to 9.8 if correct working seen Condone for full marks minor inaccuracies from rounding, such as $\sqrt{7256}$ seen May be done in steps	
			Total	4			

Question			Answer/Indicative content	Marks	Part marks and guidance	
23	a		180 ÷ (1 + 2 + 3) × 3 [= 90]	2	**M1** for 180 ÷ (1 + 2 + 3) If 0 scored, **SC1** for angles 30, 60, 90 | Condone 6 for 1 + 2 + 3 Examiner's Comments In part (a), some realised that division by (1 + 2 + 3) was required to begin with. Many did not show the second step of multiplying by 30 and simply wrote 90 or 30, 60, 90. On 'show that' questions, where the answer is given, candidates must show every step in the method for the answer to receive full credit.	
	b		7.5	4	**B1** for sin 30° or cos 60° = $^1/_2$**soi** **M2** for 15 sin 30 **oe** or **M1** for x/15 = sin 30 **oe** Examiner's Comments In part (b), the few candidates who recognised the need for an approach using trigonometry were nearly almost always successful and knew the value of sin 30 or cos 60. Many did not consider using trigonometry perhaps because there was no diagram for this part.	
			Total	6		

Question			Answer/Indicative content	Marks	Part marks and guidance		
24			40.2 nfww	3 1 AO1.3a 2 AO3.1c	M2 for $\sin[\ldots] = \frac{55}{\text{their } 85.18 \text{ to } 85.2}$ or $\tan[\ldots] = \frac{55}{\text{their } \sqrt{46^2 + 46^2}}$ or $\cos[\ldots] = \frac{\text{their } \sqrt{46^2 + 46^2}}{\text{their } 85.18 \text{ to } 85.2}$ OR M1 for indication of required angle	Accept 40° and answers rounding to 40.2 if correct working seen 0 for $\tan[\ldots] = \frac{55}{46}$ M2 for cosine rule with cos as subject eg diagram showing angle	
					Examiner's Comment: Most candidates made a very good attempt at part (a) and many scored at least 2 marks. Some of the stronger candidates calculated the internal diagonal in one step, but most used two steps. Most candidates accurately used Pythagoras' theorem in 2D, but there were many who were unable to progress to 3D. Those who found the diagonal of the base first were more successful in continuing to find the diagonal of the whole crate. Those who started by finding the diagonal of the front face as 71.7 often subtracted this from the length of the stick, yet they hadn't considered the third dimension. Some lost the final mark because of		

Question			Answer/Indicative content	Marks	Part marks and guidance	
					premature approximation. Weaker responses did not use Pythagoras' theorem at all and calculated the volume of the cuboid instead. Part (b) was less well done but here, too, there was some good work from the stronger candidates. Those who stopped at 2D Pythagoras' theorem in part (a) usually were unable to identify the correct angle to be found.	
			Total	3		
25			32.6 or 32.56 or 32.556&	5	**M2** for $\sqrt{(11^2 + 6^2)}$ soi by 12.52 to 12.53 or **M1** for $[\ldots]^2 = 11^2 + 6^2$ and **M2** for tan [… =] 8 ÷ *their* 12.52 or **M1** for 8 ÷ *their* 12.52 | accept any correct and full method note: HB = 14.866…	
					Examiner's Comments Many candidates did correctly find one of the diagonals, HF or HB, using Pythagoras' theorem. However they did not realise that the triangle was right-angled and a common method was the use of the sine or cosine rules.	
			Total	5		

Question			Answer/Indicative content	Marks	Part marks and guidance	
26	a		Attempt to use the cosine formula $[\ldots]^2 =$ $14^2 + 18^2 - 2 \times 14 \times 18 \cos 46$ oe or cosine formula with at most 2 errors or correct cosine formula starting cos $[\ldots] = \frac{14^2+18^2-[\ldots]^2}{2\times18\times14}$ 13.03…	M1 M2 or M1 A1 4	Evidenced by the formula e.g. $a^2 = b^2 + c^2 - 2bc \cos A$ or better Examiner's Comments In part (a) quite a few candidates realised that they needed to use the cosine rule but could not substitute the values correctly whilst others failed to evaluate the correct values on their calculator. A few candidates lost credit by not giving their calculated value to more than 3 significant figures as required for a 'show that' question.	
	b		35.48 to 35.6	3	B1 for 180 – 78 – 81 or 21 M1 for $\frac{13.0\ldots}{\sin their 21} = \frac{[\ldots]}{\sin 78}$ oe or better could be on diagram accept any correct method Examiner's Comments In part (b) they needed to find angle ABC first then use the sine rule. This step was found difficult by many candidates.	
			Total	7		