

GCSE

Mathematics

93702H Applications of Mathematics

Unit 2: Higher Tier

Mark scheme

93702H

June 2016

Version: 1.0 Final

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

Glossary for Mark Schemes

GCSE examinations are marked in such a way as to award positive achievement wherever possible. Thus, for GCSE Mathematics papers, marks are awarded under various categories.

M	Method marks are awarded for a correct method which could lead to a correct answer.
A	Accuracy marks are awarded when following on from a correct method. It is not necessary to always see the method. This can be implied.
B	Marks awarded independent of method.
ft	Follow through marks. Marks awarded for correct working following a mistake in an earlier step.
SC	Special case. Marks awarded within the scheme for a common misinterpretation which has some mathematical worth.
M dep	A method mark dependent on a previous method mark being awarded.
B dep	A mark that can only be awarded if a previous independent mark has been awarded.
oe	Or equivalent. Accept answers that are equivalent. eg, accept 0.5 as well as $\frac{1}{2}$
[a, b]	Accept values between a and b inclusive.
3.14...	Allow answers which begin 3.14 eg 3.14, 3.142, 3.149.
Use of brackets	It is not necessary to see the bracketed work to award the marks.

Examiners should consistently apply the following principles

Diagrams

Diagrams that have working on them should be treated like normal responses. If a diagram has been written on but the correct response is within the answer space, the work within the answer space should be marked. Working on diagrams that contradicts work within the answer space is not to be considered as choice but as working, and is not, therefore, penalised.

Responses which appear to come from incorrect methods

Whenever there is doubt as to whether a candidate has used an incorrect method to obtain an answer, as a general principle, the benefit of doubt must be given to the candidate. In cases where there is no doubt that the answer has come from incorrect working then the candidate should be penalised.

Questions which ask candidates to show working

Instructions on marking will be given but usually marks are not awarded to candidates who show no working.

Questions which do not ask candidates to show working

As a general principle, a correct response is awarded full marks.

Misread or miscopy

Candidates often copy values from a question incorrectly. If the examiner thinks that the candidate has made a genuine misread, then only the accuracy marks (A or B marks), up to a maximum of 2 marks are penalised. The method marks can still be awarded.

Further work

Once the correct answer has been seen, further working may be ignored unless it goes on to contradict the correct answer.

Choice

When a choice of answers and/or methods is given, mark each attempt. If both methods are valid then M marks can be awarded but any incorrect answer or method would result in marks being lost.

Work not replaced

Erased or crossed out work that is still legible should be marked.

Work replaced

Erased or crossed out work that has been replaced is not awarded marks.

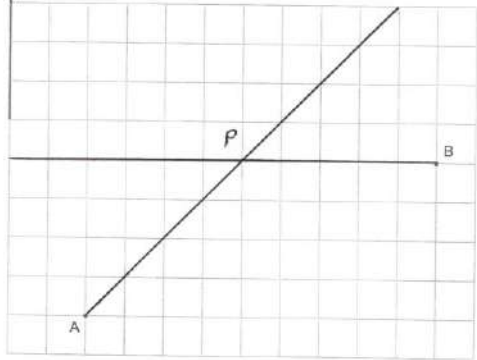
Premature approximation

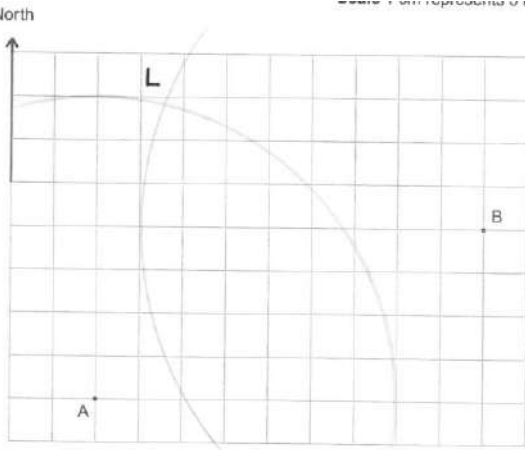
Rounding off too early can lead to inaccuracy in the final answer. This should be penalised by 1 mark unless instructed otherwise.

Continental notation

Accept a comma used instead of a decimal point (for example, in measurements or currency), provided that it is clear to the examiner that the candidate intended it to be a decimal point.

Q	Answer	Mark	Comments	
1	$4x + 57.6 = 67.2$	B1	oe equation eg1 $x + x + x + x + 57.6 = 67.2$ eg2 $4x = 9.6$ (scores M1 also) eg3 $x = \frac{67.2 - 57.6}{4}$ (scores M1 also) $x = 2.4$ with no other equation is B0	
	$4x = 67.2 - 57.6$ or $(67.2 - 57.6) \div 4$	M1	Isolates and collects term in x for their equation of form $ax + b = c$ $a > 1$ $b \neq 0$ $c \neq 0$ Allow one rearranging error	
	2.4	A1ft	ft B0 M1 with no rearranging errors SC2 2.4 with no equation seen	
	Additional Guidance			
	$3x + 57.6 = 67.2$ $3x = 9.6$ $x = 3.2$	B0 M1 A1ft		
	Embedded solutions can score 1 or 2 marks eg1 $4x = 9.6$ $4 \times 2.4 = 9.6$ (nothing on answer line) eg2 $4 \times 2.4 + 57.6 = 67.2$ (nothing on answer line)	B1 M1 A0 B0 M1 A0		
2	60	B2	B1 Any other multiple of 60 as the answer or correctly converts all 3 fractions to a common denominator eg $\frac{40}{60}$ and $\frac{36}{60}$ and $\frac{39}{60}$	
	Additional Guidance			
	Must select 60 as the answer for B2			
	60% is B0 unless B1 seen			

Q	Answer	Mark	Comments
3(a)	Bearing of 045° from A or bearing of 270° from B	M1	Allow $[043, 047]^\circ$ or $[268, 272]^\circ$
	Bearing of 045° from A and bearing of 270° from B	A1	<p style="text-align: right;">Scale 1 cm represents 5 km</p>  <p>SC1 Point P labelled in correct position but paths of ships not shown</p>
	Additional Guidance		
	Ignore additional lines eg line from A to B		
Incorrect point labelled P	A0		

Q	Answer	Mark	Comments
3(b)	Arc, centre A, radius 7 cm or arc, centre B, radius 8 cm	M1	Allow arc, centre A, radius [6.8, 7.2] cm or arc, centre B, radius [7.8, 8.2] cm
	Both arcs correct	A1	 <p>SC1 Point L labelled in correct position but arcs not shown SC1 Arc, centre A, radius [7.8, 8.2] cm and arc, centre B, radius [6.8, 7.2] cm</p>
	Additional Guidance		
	Incorrect point labelled L	A0	

Q	Answer	Mark	Comments
4	Alternative method 1		
	Any two of 6 (litres apple) 1.5 (litres orange) 1.5 (litres pineapple)	M1	oe eg working in ml Number of litres she needs to buy Implied by any two of 3 (cartons apple) 2 (cartons orange) 3 (cartons pineapple)
	(apple) $5 \div 30$ or [0.16, 0.17] or (orange/pineapple) $1.25 \div 30$ or [0.0416, 0.042]	M1	oe eg working in ml Number of litres per person
	(apple) their $6 \div$ their [0.16, 0.17] and (orange) their $1.5 \div$ their [0.0416, 0.0417] and (pineapple) their $1.5 \div$ their [0.0416, 0.0417]	M1dep	oe Division of their litres by their litres per person dep on M1 M1 If the same number of litres of orange and pineapple, only need to see their $1.5 \div$ their [0.0416, 0.0417] once
	36	Q1	Strand (ii) All three numbers of litres must be correct in 1st M1 and correct working seen for 3rd M1 SC1 36 with no M marks gained
	Additional Guidance		
Answer 36 will not always gain 4 marks			

Q	Answer	Mark	Comments
4	Alternative method 2		
	Any two of 6 (litres apple) 1.5 (litres orange) 1.5 (litres pineapple)	M1	oe eg working in ml Number of litres she needs to buy Implied by any two of 3 (cartons apple) 2 (cartons orange) 3 (cartons pineapple)
	(apple) $30 \div 5$ or 6 or (orange/pineapple) $30 \div 1.25$ or 24	M1	oe eg working in ml Number of people per litre
	(apple) their 6 x their 6 and (orange) their 1.5 x their 24 and (pineapple) their 1.5 x their 24	M1dep	oe Multiplication of their litres by their number of people per litre dep on M1 M1 If the same number of litres of orange and pineapple, only need to see their 1.5 x their 24 once
	36	Q1	Strand (ii) All three numbers of litres must be correct in 1st M1 and correct working seen for 3rd M1 SC1 36 with no M marks gained
	Additional Guidance		
Answer 36 will not always gain 4 marks			

Q	Answer	Mark	Comments
4	Alternative method 3		
	Any two of 6 (litres apple) 1.5 (litres orange) 1.5 (litres pineapple)	M1	oe eg working in ml Number of litres she needs to buy Implied by any two of 3 (cartons apple) 2 (cartons orange) 3 (cartons pineapple)
	(apple) their $6 - 5$ or 1 (l) or (orange) their $1.5 - 1.25$ or 0.25 (l) or (pineapple) their $1.5 - 1.25$ or 0.25 (l)	M1	oe eg working in ml Difference between their litres and litres needed for 30 people
	(apple) their $1 \div 5 \times 30$ or 6 and (orange) their $0.25 \div 1.25 \times 30$ or 6 and (pineapple) their $0.25 \div 1.25 \times 30$ or 6	M1dep	oe eg working in ml dep on M1 M1 If the same number of litres of orange and pineapple in 2nd M1, only need to see their $0.25 \div 1.25 \times 30$ once
	36	Q1	Strand (ii) All three numbers of litres must be correct in 1st M1 and correct working seen for 3rd M1 SC1 36 with no M marks gained
	Additional Guidance		
Answer 36 will not always gain 4 marks			

Q	Answer	Mark	Comments
4	Alternative method 4		
	Any two of 6 (litres apple) 1.5 (litres orange) 1.5 (litres pineapple)	M1	oe eg working in ml Number of litres she needs to buy Implied by any two of 3 (cartons apple) 2 (cartons orange) 3 (cartons pineapple)
	(apple) their $6 \div 5$ or 1.2 or (orange) their $1.5 \div 1.25$ or 1.2 or (pineapple) their $1.5 \div 1.25$ or 1.2	M1	oe eg working in ml Division of their litres by litres needed for 30 people Implied by $9 \div 7.5$ or $9 \div \frac{7.5}{30}$
	30 x their 1.2	M1dep	oe dep on M1 M1 Only award if three equal values are seen in 2nd M1 If the same number of litres of orange and pineapple, only need to see their $1.5 \div 1.25$ once in 2nd M1
	36	Q1	Strand (ii) All three numbers of litres must be correct in 1st M1 and correct working seen for 3rd M1 SC1 36 with no M marks gained
	Additional Guidance		
Answer 36 will not always gain 4 marks			

Q	Answer	Mark	Comments
4	Alternative method 5		
	Any two of 6 (litres apple) 1.5 (litres orange) 1.5 (litres pineapple)	M1	oe eg working in ml Number of litres she needs to buy Implied by any two of 3 (cartons apple) 2 (cartons orange) 3 (cartons pineapple)
	their 6 : their 1.5 : their 1.5 = 4 : 1 : 1 or 5 : 1.25 (: 1.25) = 4 : 1 (: 1)	M1	oe eg working in ml If the same number of litres of orange and pineapple, only need to see 6 : 1.5 = 4 : 1
	(their 6 + their 1.5 + their 1.5) × (30 ÷ (5 + 1.25 + 1.25))	M1dep	oe eg 9 ÷ 0.25 dep on M1 M1 Only award if two identical simplified ratios are seen in 2nd M1
	36	Q1	Strand (ii) All three numbers of litres must be correct in 1st M1 and correct working seen for 3rd M1 SC1 36 with no M marks gained
	Additional Guidance		
Answer 36 will not always gain 4 marks			

Q	Answer	Mark	Comments
5(a)	(5 →) 13.5 (10 →) 24 (30 →) 36 (50 →) 0	B2	B1 Two or three values correct Other values may be incorrect or missing
5(b)	Smooth quadratic curve through (0, 0), (5, 13.5), (10, 24), (20, 36), (30, 36), (40, 24) (45, 13.5) and (50, 0) All points ± 0.5 square	B2ft	Correct or ft their points from (a) for B2 or B1 B1ft At least 5 points plotted correctly All points ± 0.5 square
	Additional Guidance		
	For B2, curve must have $36.5 \leq \text{maximum } y \text{ value} \leq 39.5$		
For B2 and B1, points can be implied by their graph passing through the points			

Q	Answer	Mark	Comments
5(c)	37.5	B1ft	Correct or ft their quadratic graph if $36.5 \leq \text{answer} \leq 40$ Allow ± 0.5 square
6	11×4 or 44 (cm) or 440 (mm) or 7.5×4 or 30 (cm) or 300 (mm) or 4×4 or 16 (cm) or 160 (mm)	M1	May be on diagram Allow $[10.8, 11.2] \times 4$ or $[43.2, 44.8]$ cm or $[432, 448]$ mm or $[7.3, 7.7] \times 4$ or $[29.2, 30.8]$ cm or $[292, 308]$ mm or $[3.8, 4.2] \times 4$ or $[15.2, 16.8]$ cm or $[152, 168]$ mm
	their $440 \div 72$ or 6(.1...) or their $300 \div 72$ or 4(.1 ...) or 4.2 or their $160 \div 72$ or 2(.2 ...)	M1dep	oe eg their $44 \div 7.2$ $72 \times 6 = 432$ or $72 \times 4 = 288$ or $72 \times 2 = 144$ Implied by $(\text{their } 440 \times \text{their } 300 \times \text{their } 160) \div 72^3$ or $[56.5, 56.6]$ oe
	their $6 \times \text{their } 4 \times \text{their } 2$ or 48	M1dep	oe their 6, their 4 and their 2 must be integers from rounding down their values
	48 and decision with no incorrect working	A1	
	Additional Guidance		
Working with volumes can score a maximum of M1 M1 M0 A0			

Q	Answer	Mark	Comments	
7(a)	Alternative method 1			
	$6 : 8 (: 9)$ or 3×2 or 6 and 4×2 or 8	$(3 :) 4 : 4.5$ or $8 \div 2$ or 4 and $9 \div 2$ or 4.5	M1	oe eg1 $8 \div 4$ or 2 and 3×2 or 6 eg2 $8 \times \frac{3}{4}$ eg3 $4 \times \frac{9}{8}$
	$6 : 9 = 2 : 3$	$3 : 4.5 = 2 : 3$	A1	Must see correct working for M1 Allow $6 : 8 : 9 = 2 : 2.66 : 3$ (2.66 or better) or $6 : 8 : 9 = 2 : 2.67 : 3$
	Alternative method 2			
	$24 : 32$ and $32 : 36$ or 3×8 or 24 and 4×8 or 32 and 8×4 or 32 and 9×4 or 36	M1	Converts both ratios to equivalent ones with a common value for F oe eg $\frac{3}{4} : 1$ and $1 : \frac{9}{8}$	
	$24 : 36 = 2 : 3$	A1	oe eg $\frac{3}{4} : \frac{9}{8} = 2 : 3$ Must see correct working for M1	
	Alternative method 3			
	$3F = 4C$ and $8G = 9F$ and $12C = 8G$	M1	Must see three correct equations, one in F and C, one in G and F, one in C and G oe eg $F = \frac{4}{3}C$ and $G = \frac{9}{8}F$ and $G = \frac{36}{24}C$	
$\frac{C}{G} = \frac{8}{12} = \frac{2}{3}$ or $3C = 2G$ and $C : G = 2 : 3$	A1	oe eg $\frac{C}{G} = \frac{24}{36} = \frac{2}{3}$ Must see correct working for M1		

Q	Answer	Mark	Comments	
7(a) (cont)	Additional Guidance			
	Alt 1 and 2 For A1, must see an appropriate equivalent ratio as well as 2 : 3			
	Alt 3 For A1, must see an appropriate equivalent fraction as well as $\frac{2}{3}$			
	3 × 8 = 24 4 × 9 = 36 24 : 36 = 2 : 3		M0 A0	
	8 ÷ 4 = 2 9 ÷ 3 = 3 2 : 3		M0 A0	
7(b)	261.6 ÷ 2 (× 3) or 130.8 (× 3)	261.6 × 3 (÷ 2) or 784.8 (÷ 2)	M1	oe eg 261.6 × 1.5
	392.4		A1	
	Additional Guidance			
	261.6 ÷ 2 × 5			M0
8(a)	108 litres	B1		
8(b)	their 108 ÷ 4.5		M1	Correct or ft their (a) oe Must attempt a conversion of 4 min 30 s to minutes Allow their 108 ÷ 4.3(0)
	24		A1ft	Only ft their (a) SC1 24 000 (from 108 000 ÷ 4.5)
	Additional Guidance			
	their (a) 10.8 (b) 2.4			M1 A1
	their (a) 1080 (b) 240			M1 A1
	their (a) 10 800 (b) 2400			M1 A1
	108 ÷ 4			M0

Q	Answer	Mark	Comments
9	$\pi \times 9^2$ or 81π or [254, 254.502] or 255 or $\pi \times (10 + \frac{18}{2})^2$ or 361π or [1133.5, 1134.3] or 280π or [878.5, 880.3]	M1	oe May be on diagram Correct method for area of small circle or correct method for area of large circle or correct area of annulus
	$2 \times \pi \times 9 \times 27$ or 486π or [1526, 1527.012]	M1	oe Correct method for curved surface area
	their 486π + their 361π (– their 81π + their 81π) or [2658.5, 2662.312]	M1dep	oe must use areas involving π dep on M1 M1
	847π	A1	Must see 847π for A1 Ignore subsequent attempt to convert to a decimal
	Additional Guidance		
Using radius = 14 for the large circle leads to 682π or [2140.7, 2143.844] If first M1 seen If first M1 not seen		M1 M1 M1 A0 M0 M1 M0 A0	
3rd M1 The total surface area may be attempted as curved surface + large circle (+ small circle – small circle) or curved surface + annulus + small circle			

Q	Answer	Mark	Comments
10(a)	$300 \div 750$ or -0.4	M1	oe eg1 $\frac{300 - 0}{0 - 750}$ eg2 $-\frac{2}{5}$
	0.4 or $\frac{2}{5}$	A1	oe fraction or decimal
	Additional Guidance		
	$300 \div 750 = 0.4$ and $0.4 \div 2 = 0.2$	M0	
10(b)	$(a =) 300$	B1	
	$(b =)$ their 0.4 if their (a) is positive or $(b =)$ –their 0.4 if their (a) is negative	B1ft	Correct or ft their (a)
	Additional Guidance		
	$h = 300 - 0.4t$	B1 B1	

Q	Answer	Mark	Comments
10(c)	Alternative method 1		
	$80 = 300 - 0.4t$	M1	Correct or ft their a and their b from (b) $a \neq 0$ $b \neq 0$ Must use 80 for h
	$0.4t = 300 -$ their 80	M1	oe eg $0.4t = 220$ (implies M1 M1) Correct or ft their a and their b from (b) $a \neq 0$ $b \neq 0$
	550 (minutes)	A1ft	Correct or ft their a and their b from (b) Must score M1 M1
	9 (hours) 10 (minutes)	B1ft	Only ft if their $550 > 60$ and is not a multiple of 60
	Alternative method 2		
	$\frac{80}{300} \times 750$ or $750 \div \frac{300}{80}$ or 200	M1	oe eg $80 \div 0.4$ or $750 \div 3.75$
	750 – their 200	M1dep	M2 $\frac{300 - 80}{300} \times 750$ or $220 \div 0.4$ or $750 \div \frac{300}{300 - 80}$ oe
	550 (minutes)	A1	
	9 (hours) 10 (minutes)	B1ft	Only ft if their $550 > 60$ and is not a multiple of 60
	Additional Guidance		
Alt 1 If $a = 300$ and their $b = 2.5$ 88 (min) 1h 28 min		M1 M1 A1ft B1ft	

Q	Answer	Mark	Comments
11(a)	$\frac{1}{2} \times 12 \times 6$ or $\frac{1}{2} \times 10 \times 8$	M1	oe eg $\frac{1}{2} \times 3 \times 6 (+) \frac{1}{2} \times (12 - 3) \times 6$
	36 or 40	A1	
	36 and 40 and Finn	Q1	Strand (ii) Two correct areas and correct decision
11(b)	Attempt at gradient of Finn's graph	M1	eg $\frac{8-0}{10-0}$ Allow a gradient attempt using squares from the graph eg $\frac{4}{10}$ or $\frac{2}{5}$
	$\frac{8}{10}$ or $\frac{4}{5}$ or 0.8	A1	oe
	m/s^2 or ms^{-2} or m/s/s or metres per second per second	B1	oe

Q	Answer	Mark	Comments
12(a)	Alternative Method 1		
	$\cos a = \frac{3.49}{3.5}$ or $\sin a = \frac{\sqrt{3.5^2 - 3.49^2}}{3.5}$ or $\tan a = \frac{\sqrt{3.5^2 - 3.49^2}}{3.49}$	M1	oe $\cos a = \frac{3.5^2 + 3.49^2 - (3.5^2 - 3.49^2)}{2 \times 3.5 \times 3.49}$ or $\sin a = \frac{\sin 90}{3.5} \times \sqrt{3.5^2 - 3.49^2}$
	$\cos^{-1} \frac{3.49}{3.5}$ or $\sin^{-1} \frac{\sqrt{3.5^2 - 3.49^2}}{3.5}$ or $\tan^{-1} \frac{\sqrt{3.5^2 - 3.49^2}}{3.49}$ or [4.3, 4.4]	M1dep	oe $\cos^{-1} \frac{3.5^2 + 3.49^2 - (3.5^2 - 3.49^2)}{2 \times 3.5 \times 3.49}$ or $\sin^{-1} \frac{\sin 90}{3.5} \times \sqrt{3.5^2 - 3.49^2}$ This mark implies M2
	[4.3, 4.4] and No	A1	Compares to 3.8(0)
	Alternative Method 2		
	$\cos 3.8(0) = \frac{x}{3.5}$	M1	x is the horizontal
	$\cos 3.8(0) \times 3.5$ or 3.492...	M1dep	This mark implies M2
	3.492... and No or (x is) > 3.49 and No	A1	Compares to 3.49
	Additional Guidance		
	Working in rads or grads can score up to both M marks if correct working seen		

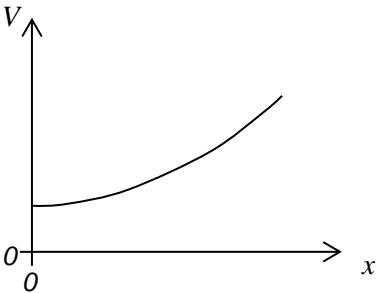
Alternative Method 3 is on the next page

Q	Answer	Mark	Comments
	Alternative Method 3		
	$\cos 3.8(0) = \frac{3.49}{y}$	M1	y is the length of the ramp
	3.49 ÷ cos 3.8(0) or [3.497, 3.498]	M1dep	This mark implies M2
	[3.497, 3.498] and No or (y is) < 3.5 and No	A1	Compares to 3.5
	Additional Guidance		
	Working in rads or grads can score up to both M marks if correct working seen		

Q	Answer	Mark	Comments
12(b)	2.85 for angle on first ramp	B1	May be implied by working or seen on diagram
	5 for length of second ramp	B1	May be implied by working or seen on diagram
	$\sin(\text{their } 2.85) = \frac{x}{8.7}$ or $\sin(3.8(0)) = \frac{y}{\text{their } 5}$	M1	x is height of 1st ramp oe eg1 $8.7^2 - (8.7 \times \cos \text{their } 2.85)^2$ y is height of 2nd ramp oe eg2 $\text{their } 5^2 - (\text{their } 5 \times \cos 3.8(0))^2$
	$8.7 \times \sin(\text{their } 2.85) +$ $\text{their } 5 \times \sin(3.8(0))$ or $0.43... + 0.33...$	M1dep	oe eg $\sqrt{8.7^2 - (8.7 \times \cos \text{their } 2.85)^2}$ $+ \sqrt{\text{their } 5^2 - (\text{their } 5 \times \cos 3.8(0))^2}$
	[0.76, 0.764]	A1	Allow 0.8 if correct method seen
	Additional Guidance		
	Working in rads or grads can score up to both B and both M marks if correct working seen		
	Other alternatives for M marks $\cos(90 - \text{their } 2.85) = \frac{x}{8.7}$ or $\cos(90 - 3.8(0)) = \frac{y}{\text{their } 5}$ $8.7 \times \cos(90 - \text{their } 2.85) + \text{their } 5 \times \cos(90 - 3.8(0))$		

Q	Answer	Mark	Comments
13(a)	$200\,000 \div 10\,000 (= 20)$ or $A \times c^0$ or $c^0 = 1$	M1	Allow $10\,000 \times 20 = 200\,000$ or $200\,000 \div 20 = 10\,000$
	$20 = A \times c^0$ or $\frac{200\,000}{10\,000} = A \times c^0$ and $c^0 = 1$ and $A = 20$	Q1	Strand (ii) Fully correct response that must show substitution of $V = 20$ or $\frac{200\,000}{10\,000}$ and $x = 0$ in $V = A \times c^x$ and indication that $c^0 = 1$ leading to $A = 20$
	Additional Guidance		
$200\,000 = A \times c^0$ $200\,000 = A \times 1$ $200\,000 = A$ $200\,000 \div 10\,000 = A$ $A = 20$	M1 Q0 Scores Q0 because has not shown substitution of $V = 20$ and $x = 0$		

Q	Answer	Mark	Comments
13(b)	Alternative method 1		
	$(V \Rightarrow) 220\,500 \div 10\,000$ or 22.05	M1	A = 22.05 is M0
	their 22.05 = $20 \times c^2$ or $\frac{\text{their } 22.05}{20}$ or 1.1025	M1	oe their 22.05 cannot be 220 500 If no method seen for 1st M1 their 22.05 must be digits 22...
	$\sqrt{\frac{\text{their } 22.05}{20}}$ or $\sqrt{1.1025}$	M1dep	oe dep on 2 nd M1
	1.05 or $\frac{21}{20}$	A1	oe SC1 105
	Alternative method 2		
	$\frac{220\,500}{200\,000}$ or 1.1025	M2	oe
	$\sqrt{\frac{220\,500}{200\,000}}$ or $\sqrt{1.1025}$	M1dep	oe
	1.05 or $\frac{21}{20}$	A1	oe SC1 105
	Additional Guidance		
	1.05 and -1.05 or only -1.05		A0

Q	Answer	Mark	Comments
13(c)	<p>Curve starting from point on vertical axis above (0, 0) showing exponential increase</p> 	B2ft	<p>Correct or ft $0 < c < 1$ for B2 and B1 B1 Curve showing exponential increase or any graph starting from point on vertical axis above (0, 0)</p>
	Additional Guidance		
	If $0 < c < 1$, allow a curve showing exponential increase or decrease		
	If their $c = 1$, allow a curve showing exponential increase		

Q	Answer	Mark	Comments
14	$\frac{168}{360}$ or 0.46(...) or 0.47 or $2 \times \pi \times 150$ or 300π or [942, 942.6] or $2 \times \pi \times 82$ or 164π or [514.9, 515.3]	M1	oe
	$\frac{168}{360} \times 2 \times \pi \times 150$ or 140π or [439.6, 439.9]	M1	oe This mark implies the first M1
	$\frac{168}{360} \times 2 \times \pi \times 82$ or $\frac{1148}{15}\pi$ or [240.3, 240.5]	M1	oe This mark implies the first M1 $\frac{168}{360} \times 2 \times \pi \times (150 + 82)$ or $\frac{3248}{15}\pi$ or [679.9, 680.4] scores M3 unless further work involving another arc is seen
	their [439.6, 439.9] + their [240.3, 240.5] + $2 \times (150 - 82)$ or [815.9, 816.4]	M1dep	oe dep on 2 nd and 3 rd M1
	816	A1	SC2 476
	Additional Guidance		
$\frac{168}{360} \times 2 \times \pi \times (150 + 82) + \frac{168}{360} \times 2 \times \pi \times 82$			M1 M0 M1 M0 A0

Q	Answer	Mark	Comments
15(a)	$16^2 + 10^2$ or 356 or $16^2 + 5^2$ or 281 or $10^2 + 5^2$ or 125 or 381	M1	oe eg working in mm Implied by $2\sqrt{89}$ or 18.8(...) or 18.9 Implied by 16.7(...) or 16.8 Implied by $5\sqrt{5}$ or 11.1(...) or 11.2
	$\sqrt{16^2 + 10^2 + 5^2}$ or $\sqrt{381}$ or [19.51, 19.52]	M1dep	oe eg $\sqrt{18.9^2 + 5^2}$ or working in mm This mark implies M2
	19.5	A1	
	Additional Guidance		
	19 cm [5, 5.2] mm		

Q	Answer	Mark	Comments
15(b)	$\tan x = \frac{5}{\sqrt{16^2 + 10^2}}$ or $\sin x = \frac{5}{\sqrt{16^2 + 10^2 + 5^2}}$ or $\sin x = \frac{5}{\text{their } 19.5}$ or $\cos x = \frac{\sqrt{16^2 + 10^2}}{\sqrt{16^2 + 10^2 + 5^2}}$ or $\cos x = \frac{\sqrt{16^2 + 10^2}}{\text{their } 19.5}$	M1	oe eg working in mm x is the required angle Only ft their 19.5 if this is a diagonal of the cuboid in (a) $\cos x = \frac{16^2 + 10^2 + 5^2 + 16^2 + 10^2 - 5^2}{2 \times \sqrt{16^2 + 10^2 + 5^2} \times \sqrt{16^2 + 10^2}}$ or $\sin x = \frac{\sin 90}{\sqrt{16^2 + 10^2 + 5^2}} \times 5$
	[14.6, 14.9]		A1ft
Additional Guidance			
If their longest pencil in (a) is along a diagonal of a face, do not ft in (b)			
For A1ft accept rounding to 1dp or nearest degree with M1 seen			
Working in rads or grads can score M1 if correct working seen			

Q	Answer	Mark	Comments
16(a)	$4 \times 4 \times 4$ or 64	M1	oe
	$\frac{1}{3} \times 4 \times 4 \times 2.5$	M1	oe method Allow $0.33 \times 4 \times 4 \times 2.5$ (0.33 or better)
	$4 \times 4 \times 4 + \frac{1}{3} \times 4 \times 4 \times 2.5 = 77\frac{1}{3}$ or $64 + \frac{1}{3} \times 4 \times 4 \times 2.5 = 77\frac{1}{3}$	A1	oe Do not accept 77.3 Must have final answer $77\frac{1}{3}$
	Additional Guidance		
	$64 + 13\frac{1}{3} = 77\frac{1}{3}$ with no method seen for $13\frac{1}{3}$		M1 M0 A0
	$64 + \frac{1}{3} \times 4 \times 4 \times 2.5 = \frac{232}{3} = 77\frac{1}{3}$ $64 + \frac{1}{3} \times 4 \times 4 \times 2.5 = 64 + \frac{40}{3} = \frac{232}{3}$		M1 M1 A1 M1 M1 A0
	Allow use of 0.33 or better throughout but final answer must be $77\frac{1}{3}$ $4 \times 4 \times 4 + 0.33 \times 4 \times 4 \times 2.5 = 77.33 = 77\frac{1}{3}$ $4 \times 4 \times 4 + 0.33 \times 4 \times 4 \times 2.5 = 77.33$ $4 \times 4 \times 4 + 0.3 \times 4 \times 4 \times 2.5 = 77.3 = 77\frac{1}{3}$		M1 M1 A1 M1 M1 A0 M1 M0 A0

Q	Answer	Mark	Comments
16(b)	Alternative method 1		
	1.827 × 1000 ÷ 7 or 261	M1	oe eg 1.827 ÷ (7 ÷ 1000) large volume
	their 261 ÷ 77 $\frac{1}{3}$ or $\frac{27}{8}$ or 3.375	M1dep	oe large volume ÷ small volume
	$\sqrt[3]{\text{their } 3.375}$	M1dep	
	1.5 with no incorrect working	A1	oe
	Alternative method 2		
	7 × 77 $\frac{1}{3}$ or 541 $\frac{1}{3}$ or $\frac{1618}{3}$	M1	oe small mass
	1.827 × 1000 ÷ their 541 $\frac{1}{3}$ or $\frac{27}{8}$ or 3.375	M1dep	oe large mass ÷ small mass
	$\sqrt[3]{\text{their } 3.375}$	M1dep	
	1.5 with no incorrect working	A1	oe
	Additional Guidance		
	For M marks, allow use of 0.3 (or better) for $\frac{1}{3}$		
	T & I scores full marks or zero		