

# Markscheme

November 2015

Mathematical Studies

Standard level

Paper 2

This markscheme is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Assessment Centre.

**Paper 2 Markscheme  
Instructions to Examiners**

**Notes:** If in doubt about these instructions or any other marking issues, contact your team leader for clarification.

**1 Abbreviations**

- M** Marks awarded for **Method**
- A** Marks awarded for an **Answer** or for **Accuracy**
- R** Marks awarded for clear **Reasoning**
- G** Marks awarded for correct solutions obtained from a **Graphic Display Calculator**, when no working shown.
- AG Answer Given** in the question and consequently, marks not awarded.
- ft** Marks that can be awarded as **follow through** from previous results in the question.

**2 Method of Marking**

- (a) All marking must be done in RM Assessor using the mathematical studies annotations and in accordance with the current document for guidance in e-marking Mathematical Studies SL. It is essential that you read this document before you start marking.
- (b) If a question part is completely correct use the number tick annotations to award full marks. If a part is completely wrong use the **A0** annotation, otherwise full annotations must be shown.
- (c) Working crossed out by the candidate should not be awarded any marks.
- (d) Where candidates have written two solutions to a question, only the first solution should be marked.
- (e) If correct working results in a correct answer but then further working is developed, indicating a lack of mathematical understanding full marks should **not** be awarded. In most such cases it will be a single final answer mark that is lost. An exception to this may be in numerical answers, where a correct exact value is followed by an incorrect decimal.

**Example:**

	Correct answer seen	Further working seen	Action
1.	$8\sqrt{2}$	5.65685... (incorrect decimal value)	Award the final <b>(A1)</b> (ignore the further working)
2.	$(x-6)(x+1)$	$x=6$ and $-1$	Do <b>not</b> award the final <b>(A1)</b>

**Example:** Calculate the gradient of the line passing through the points (5, 3) and (0, 9).

Markscheme	Candidates' Scripts	Marking
$\frac{9-3}{0-5}$ <b>(M1)</b> Award <b>(M1)</b> for correct substitution in gradient formula  $= -\frac{6}{5}$ <b>(A1)</b>	(i) $\frac{9-3}{0-5} = -\frac{6}{5}$	<b>(M1)</b>
	Gradient is $= -\frac{6}{5}$	<b>(A1)</b>
	$y = -\frac{6}{5}x + 9$	(There is clear understanding of the gradient.)
	(ii) $\frac{9-3}{0-5} = -\frac{6}{5}$	<b>(M1)</b>
	$y = -\frac{6}{5}x + 9$	<b>(A0)</b>
	(There is confusion about what is required.)	

**3 Follow-through (ft) Marks**

Errors made at any step of a solution affect all working that follows. To limit the severity of the penalty, **follow through (ft)** marks can be awarded. Mark schemes will indicate where it is appropriate to apply follow through in a question with '(ft)'.

- (a) Follow through applies only from one part of a question to a subsequent part of the question. Follow through does not apply within the same part.
- (b) If an answer resulting from follow through is extremely unrealistic (eg, negative distances or incorrect by large order of magnitude) then the final **A** mark should not be awarded.
- (c) If a question is transformed by an error into a **different, much simpler question** then follow through may not apply.
- (d) To award follow through marks for a question part, **there must be working present for that part**. An isolated follow through answer, without working is regarded as incorrect and receives no marks **even if it is approximately correct**.
- (e) The exception to the above would be in a question which is testing the candidate's use of the GDC, where working will not be expected. **The markscheme will clearly indicate where this applies**.
- (f) Inadvertent use of radians will be penalized the first time it occurs. The markscheme will give clear instructions to ensure that only one mark per paper can be lost for the use of radians.

**Example:** Finding angles and lengths using trigonometry

Markscheme	Candidates' Scripts	Marking
<p>(a) <math>\frac{\sin A}{3} = \frac{\sin 30}{4}</math> <b>(M1)(A1)</b>                      Award <b>(M1)</b> for substitution in sine rule formula, <b>(A1)</b> for correct substitutions.</p> <p><math>A = 22.0^\circ</math> (22.0243...) <b>(A1)(G2)</b></p>	<p>(a) <math>\frac{\sin A}{4} = \frac{\sin 30}{3}</math></p> <p><math>A = 41.8^\circ</math>                      (<b>Note:</b> the 2<sup>nd</sup> <b>(A1)</b> here was not marked <b>(ft)</b> and cannot be awarded because there was an earlier error in the <b>same</b> question part.)</p>	<p><b>(M1)(A0)</b>                      (use of sine rule but with wrong values)</p> <p><b>(A0)</b></p>
<p>(b) <math>x = 7 \tan (22.0243\dots^\circ)</math> <b>(M1)</b>  <math>= 2.83</math> (2.83163...) <b>(A1)(ft)</b></p>	<p>(b) case (i) <math>x = 7 \tan 41.8^\circ</math>  <math>= 6.26</math></p> <p><b>but</b> case (ii) 6.26</p>	<p><b>(M1)</b>  <b>(A1)(ft)</b>  <b>(G0)</b>                      since no working shown</p>

**4 Using the Markscheme**

(a) **A** marks are **dependent** on the preceding **M** mark being awarded, it is **not** possible to award **(M0)(A1)**. Once an **(M0)** has been awarded, all subsequent **A** marks are lost in that part of the question, even if calculations are performed correctly, until the next **M** mark.

The only exception to this will be for an answer where the accuracy is specified in the question – see section 5.

(b) **A** marks are **dependent** on the **R** mark being awarded, it is **not** possible to award **(A1)(R0)**. Hence the **(A1)** cannot be awarded for an answer which is correct when no reason or the wrong reason is given.

(c) In paper 2 candidates are expected to demonstrate their ability to communicate mathematics using appropriate working. Answers which are correct but not supported by adequate working will **not always receive full marks**, these unsupported answers are designated **G** in the mark scheme as an alternative to the full marks. Example **(M1)(A1)(A1)(G2)**.

**Example:** Using trigonometry to calculate an angle in a triangle.

Markscheme	Candidates' Scripts	Marking
(a) $\frac{\sin A}{3} = \frac{\sin 30}{4}$ <b>(M1)(A1)</b> Award <b>(M1)</b> for substitution in sine rule formula, <b>(A1)</b> for correct substitutions.  $A = 22.0^\circ$ (22.0243...) <b>(A1)(G2)</b>	(i) $\frac{\sin A}{3} = \frac{\sin 30}{4}$ $A = 22.0^\circ$  (ii) $A = 22.0^\circ$	<b>(M1)(A1)</b>  <b>(A1)</b>  <b>(G2)</b> <b>Note: G marks are used only if no working has been shown and the answer is correct.</b>

(d) **Alternative methods** may not always be included. Thus, if an answer is wrong then the working must be carefully analysed in order that marks are awarded for a different method consistent with the markscheme.

Where alternative methods for complete questions are included in the markscheme, they are indicated by **'OR'** etc.

(e) Unless the question specifies otherwise, accept **equivalent forms**. For example:  $\frac{\sin \theta}{\cos \theta}$  for  $\tan \theta$ .

On the markscheme, these equivalent numerical or algebraic forms will sometimes be written in brackets after the required answer.

Where numerical answers are required as the final answer to a part of a question in the markscheme, the scheme will show, in order:

the 3 significant figure answer worked through from full calculator display;

the exact value  $\left( \text{for example } \frac{2}{3} \text{ if applicable} \right)$ ;

the full calculator display in the form 2.83163... as in the example above.

Where answers are given to 3 significant figures and are then used in subsequent parts of the question leading to a **different** 3 significant figure answer, these solutions will also be given.

- (f) As this is an international examination, all valid **alternative forms of notation** should be accepted. Some examples of these are:

Decimal points: 1.7; 1'7; 1·7; 1,7 .

Decimal numbers less than 1 may be written with or without a leading zero: 0.49 or .49 .

Different descriptions of an interval:  $3 < x < 5$ ;  $(3, 5)$ ;  $] 3, 5 [$  .

Different forms of notation for set properties (eg, complement):  $A'$ ;  $\bar{A}$ ;  $A^c$ ;  $U - A$ ;  $(A; U \setminus A$ .

Different forms of logic notation:  $\neg p$ ;  $p'$ ;  $\tilde{p}$ ;  $\bar{p}$ ;  $\sim p$ .

$p \Rightarrow q$ ;  $p \rightarrow q$ ;  $q \Leftarrow p$  .

Significance level may be written as  $\alpha$  .

- (g) Discretionary marks: There will be very rare occasions where the markscheme does not cover the work seen. In such cases the annotation DM should be used to indicate where an examiner has used discretion. Discretion should be used sparingly and if there is doubt and exception should be raised through RM Assessor to the team leader.

As with previous sessions there will be no whole paper penalty marks for accuracy AP, financial accuracy FP and units UP. Instead these skills will be assessed in particular questions and the marks applied according to the rules given in sections 5, 6 and 7 below.

**5 Accuracy of Answers**

**Incorrect accuracy should be penalized once only in each question according to the rules below.**

Unless otherwise stated in the question, all numerical answers should be given exactly or correct to 3 significant figures.

1. If the **candidate’s answer** is seen to 4 sf or greater **and** would round to the required 3 sf answer, then award **(A1)** and ignore subsequent rounding.
2. If the candidate’s unrounded answer is **not** seen then award **(A1)** if the answer given is **correctly** rounded to 2 or more significant figures, otherwise **(A0)**.

**Note:** If the candidate’s unrounded answer is **not** seen and the answer is given correct to 1 sf (correct or not), the answer will be considered wrong and will not count as incorrect accuracy. If this answer is used in subsequent parts, then working must be shown for further marks to be awarded.

3. If a correct 2 sf answer is used in subsequent parts, then working **must** be shown for further marks to be awarded. (This treatment is the same as for following through from an incorrect answer.)

These 3 points (see numbers in superscript) have been summarized in the table below and illustrated in the examples following.

		If candidates final answer is given ...					
		Exact or to 4 or more sf (and would <b>round to the correct 3 sf</b> )	<b>Correct to 3 sf</b>	<b>Incorrect to 3 sf</b>	Correct to 2 sf <sup>3</sup>	Incorrect to 2 sf	Correct or incorrect to 1 sf
Unrounded answer seen <sup>1</sup>	Award the final <b>(A1)</b> irrespective of correct or incorrect rounding						
Unrounded answer not seen <sup>2</sup>	<b>(A1)</b>	<b>(A1)</b>	<b>(A0)</b>	<b>(A1)</b>	<b>(A0)</b>	<b>(A0)</b>	
Treatment of subsequent parts	As per MS		Treat as follow through, only if working is seen. <sup>3</sup>				

Examples:

Markscheme	Candidates' Scripts	Marking
9.43 (9.43398...) <b>(A1)</b>	(i) 9.43398... is seen followed by 9; 9.4; 9.43; 9.434 etc. (correctly rounded)	<b>(A1)</b>
	(ii) 9.43398... is seen followed by 9.433; 9.44 etc. (incorrectly rounded)	<b>(A1)</b>
	(iii) 9.4	<b>(A1)</b>
	(iv) 9 <i>sf</i>	<b>(A0)</b> <i>(correct to 1 sf)</i>
	(v) 9.3	<b>(A0)</b> <i>(incorrectly rounded to 2 sf)</i>
	(vi) 9.44	<b>(A0)</b> <i>(incorrectly rounded to 3 sf)</i>

Markscheme	Candidates' Scripts	Marking
7.44 (7.43798...) <b>(A1)</b>	(i) 7.43798... is seen followed by 7; 7.4; 7.44; 7.438 etc. (correctly rounded)	<b>(A1)</b>
	(ii) 7.43798... is seen followed by 7.437; 7.43 etc. (incorrectly rounded)	<b>(A1)</b>
	(iii) 7.4	<b>(A1)</b>
	(iv) 7	<b>(A0)</b> <i>(correct to 1 sf)</i>
	(v) 7.5	<b>(A0)</b> <i>(incorrectly rounded to 2 sf)</i>
	(vi) 7.43	<b>(A0)</b> <i>(incorrectly rounded to 3 sf)</i>

**Example:** ABC is a right angled triangle with angle  $ABC = 90^\circ$ ,  $AC = 32$  cm and  $AB = 30$  cm. Find (a) the length of BC, (b) The area of triangle ABC.

Markscheme	Candidates' Scripts	Marking
(a) $BC = \sqrt{32^2 - 30^2}$ <b>(M1)</b> Award <b>(M1)</b> for correct substitution in Pythagoras' formula  $= 11.1 (\sqrt{124}, 11.1355\dots)$ (cm) <b>(A1)</b>	(a) $BC = \sqrt{32^2 - 30^2}$  11 (cm)  <i>(2 sf answer only seen, but correct)</i>	<b>(M1)</b>  <b>(A1)</b>
(b) $\text{Area} = \frac{1}{2} \times 30 \times 11.1355\dots$ <b>(M1)</b> Award <b>(M1)</b> for correct substitution in area of triangle formula  $= 167(167.032\dots)$ (cm <sup>2</sup> ) <b>(A1)(ft)</b>	(b) case (i) $\text{Area} = \frac{1}{2} \times 30 \times 11$  $= 165$ (cm <sup>2</sup> )  case (ii) $= 165$ (cm <sup>2</sup> )  <i>(No working shown, the answer 11 is treated as a ft, so no marks awarded here)</i>	<b>(M1)</b> <i>(working shown)</i>  <b>(A1)(ft)</b>  <b>(M0)(A0)(ft)</b>

Certain answers obtained from the GDC are worth 2 marks and working will not be seen. In these cases only one mark should be lost for accuracy.

eg, Chi-squared, correlation coefficient, mean

Markscheme	Candidates' Scripts	Marking
Chi-squared	(a) 7.7	<b>(G2)</b>
7.68 (7.67543...) <b>(A2)</b>	(b) 7.67	<b>(G1)</b>
	(c) 7.6	<b>(G1)</b>
	(d) 8	<b>(G0)</b>
	(e) 7	<b>(G0)</b>
	(e) 7.66	<b>(G0)</b>

Regression line

Markscheme	Candidates' Scripts	Marking
$y = 0.888x + 13.5$ <b>(A2)</b> ( $y = 0.887686\dots x + 13.4895\dots$ ) If an answer is not in the form of an equation award at most <b>(A1)(A0)</b> .	(a) $y = 0.89x + 13$	<b>(G2)</b> (both accepted)
	(b) $y = 0.88x + 13$	<b>(G1)</b> (one rounding error)
	(c) $y = 0.88x + 14$	<b>(G1)</b> (rounding error repeated)
	(d) (i) $y = 0.9x + 13$	<b>(G1)</b> (1 sf not accepted)
	(ii) $y = 0.8x + 13$	
(e) $0.88x + 13$	<b>(G0)</b> (one rounding error and not an equation)	

Maximum/minimum/points of intersection

Markscheme	Candidates' Scripts	Marking
(2.06, 4.49) <b>(A1)(A1)</b> (2.06020..., 4.49253...)	(a) (2.1, 4.5)	<b>(A1)(A1)</b> (both accepted)
	(b) (2.0, 4.4)	<b>(A1)</b> (same rounding error twice)
	(c) (2.06, 4.4)	<b>(A1)</b> (one rounding error)
	(d) (2, 4.4)	<b>(A0)</b> (1sf not accepted, one rounding error)

Rounding of an exact answer to 3 significant figures **should be accepted if performed correctly**.

Exact answers such as  $\frac{1}{4}$  can be written as decimals to fewer than 3 significant figures if the result is still exact. Reduction of a fraction to its lowest terms is **not** essential, however where an answer simplifies to an integer this is expected.

Ratios of  $\pi$  and answers taking the form of square roots of integers or any rational power of an integer (eg,  $\sqrt{13}, 2^{\frac{2}{3}}, \sqrt[4]{5}$ , ) may be accepted as exact answers. All other powers (eg, of non-integers) and values of transcendental functions such as sine and cosine must be evaluated.

**If the level of accuracy is specified in the question, a mark will be allocated for giving the answer to the required accuracy.** In **all** such cases the final mark is not awarded if the rounding does not follow the instructions given in the question. A mark for specified accuracy can be regarded as a **(ft)** mark regardless of an immediately preceding **(M0)**.

**6 Level of accuracy in finance questions**

The accuracy level required for answers will be specified in all questions involving money. This will usually be either whole units or two decimal places. The first answer not given to the specified level of accuracy will not be awarded the final **A** mark. The markscheme will give clear instructions to ensure that only one mark per paper can be lost for incorrect accuracy in a financial question.

**Example:** A financial question demands accuracy correct to 2 dp.

Markscheme	Candidates' Scripts	Marking
\$231.62 (231.6189) <b>(A1)</b>	(i) 231.6	<b>(A0)</b>
	(ii) 232	<b>(A0)</b> <i>(Correct rounding to incorrect level)</i>
	(iii) 231.61	<b>(A0)</b>
	(iv) 232.00	<b>(A0)</b> <i>(Parts (iii) and (iv) are both incorrect rounding to correct level)</i>

**7 Units in answers**

There will be specific questions for which the units are required and this will be indicated clearly in the markscheme. The first correct answer with no units or incorrect units will not be awarded the final **A** mark. The markscheme will give clear instructions to ensure that only one or two mark per paper can be lost for lack of units or incorrect units.

The units are considered only when the numerical answer is awarded **(A1)** under the accuracy rules given in Section 5.

**Example:**

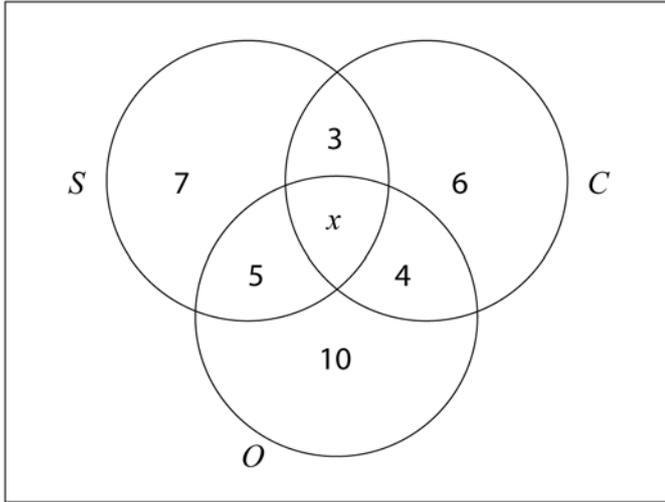
Markscheme	Candidates' Scripts	Marking
(a) 37000 m <sup>2</sup> <b>(A1)</b>	(a) 36000 m <sup>2</sup>	<b>(A0)</b> <i>(Incorrect answer so units not considered)</i>
(b) 3200 m <sup>3</sup> <b>(A1)</b>	(b) 3200 m <sup>2</sup>	<b>(A0)</b> <i>(Incorrect units)</i>

**If no method is shown and the answer is correct but with incorrect or missing units award G marks with a one mark penalty.**

**8 Graphic Display Calculators**

Candidates will often be obtaining solutions directly from their calculators. They must use mathematical notation, not calculator notation. No method marks can be awarded for incorrect answers supported only by calculator notation. The comment 'I used my GDC' cannot receive a method mark.

1. (a) U



(A1)(A1)(A1)(A1)

**Notes:** Award **(A1)** for 3 labelled intersecting circles and rectangle, and **(A1)** for  $x$ , **(A1)** for 3, 4, 5, **(A1)** for 6, 7, 10 (all in the correct place). Award **(A0)** for the appearance of 2 rather than  $x$  on the diagram.

[4 marks]

(b)  $50 - (7 + 3 + 6 + 4 + 5 + 10 + 13)$  OR  $50 - 48$

(M1)

**Note:** Award **(M1)** for setting up a correct expression involving 50 and values from **their** diagram.

$(x =) 2$

(A1)(ft)(G2)

**Note:** Follow through from their Venn diagram in part (a).

[2 marks]

(c) (i)  $\frac{17}{50}$  (0.34, 34%)

(A1)(ft)(A1)(G2)

**Note:** Award **(A1)(ft)** for correct numerator, **(A1)** for 50. 17 on its own earns **(A0)**. Follow through from parts (a) and (b).

(ii)  $\frac{21}{50}$  (0.42, 42%)

(A1)(ft)(A1)(G2)

**Note:** Award **(A1)(ft)** for correct numerator, **(A1)** for 50. 21 on its own earns **(A0)**. Follow through from parts (a) and (b).

continued...

Question 1 continued

(iii) they are not independent

(A1)(ft)

$$\frac{17}{50} \times \frac{21}{50} \neq \frac{7}{50}$$

(R1)

**Note:** Do not accept  $0.1428 = 0.14$  through premature rounding.  
Do not award **(A1)(R0)**.  
Follow through from parts (c)(i), (c)(ii) and part (b).

[6 marks]

(d)  $\frac{5}{15} \left( \frac{1}{3}, 0.333, 33.3\% \right)$

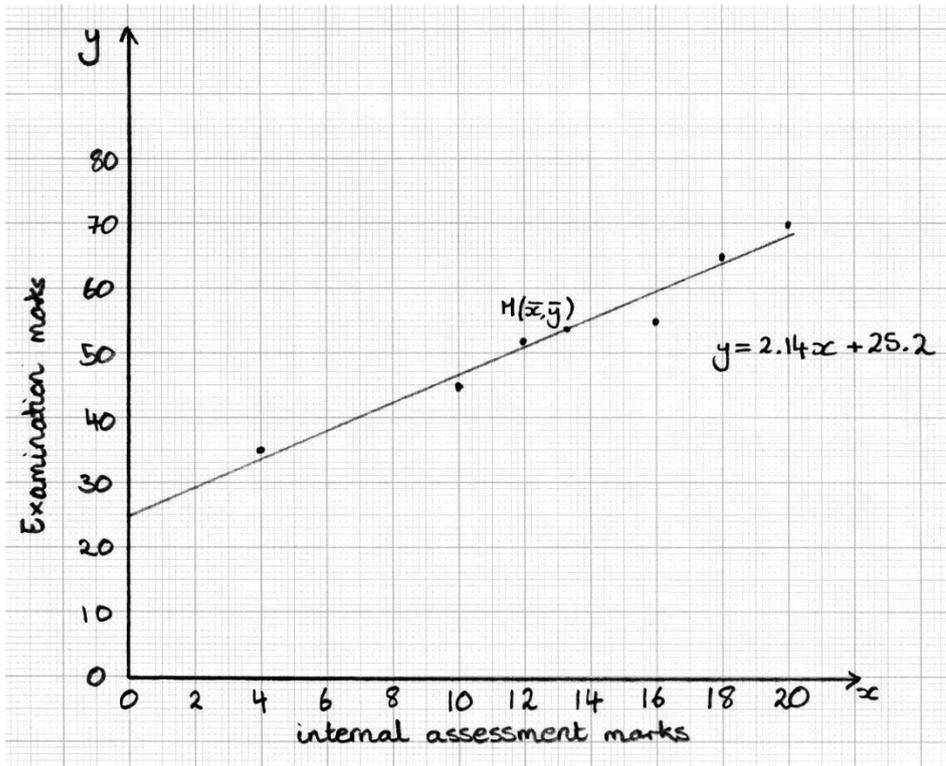
(A1)(ft)(A1)(ft)(G2)

**Note:** Award **(A1)(ft)** for numerator, **(A1)(ft)** for denominator. Follow through from parts (a) and (b).

[2 marks]

**Total [14 marks]**

2. (a)



(A3)

**Notes:** Award (A1) for correct labels and scales.  
 Accept  $x$  and  $y$  labelled on the axes as sufficient for labelling.  
 Award (A2) for all 6 points correct, (A1) for 4 or 5 points correct, otherwise (A0).  
 Award, at most, (A0)(A2) if axes are the wrong way round.  
 Award, at most, (A0)(A2) if the points are joined by lines.  
 If graph paper is not used, award at most (A1)(A0).

[3 marks]

(b) (i) 0.981 (0.981193...)

(G2)

(ii) (very) strong positive

(A1)(ft)  
(A1)(ft)

**Note:** Follow through from part (b)(i).

[4 marks]

(c) (i) 13.3 (13.3333...)

(A1)

(ii) 53.7 (53.6666...)

(A1)

[2 marks]

continued...

Question 2 continued

(d) point M labelled, in correct position (A1)(A1)(ft)

**Note:** Award (A1)(ft) for point plotted in correct position, (A1) for point labelled M or  $(\bar{x}, \bar{y})$  or (13.3, 53.7). Follow through from part (c).  
Allow tolerance of  $\pm 0.3$  on both values for  $(\bar{x}, \bar{y})$  for (A1)(ft).  
An incorrectly plotted point (outside of tolerance) earns (A0)(A0).  
If graph paper not used, award at most (A1)(A0).

[2 marks]

(e)  $y = 2.14x + 25.2$  ( $y = 2.13846\dots x + 25.1538\dots$ ) (A1)(A1)(G2)

**Note:** Award (A1) for "2.14x" and (A1) for "25.2".  
Award at most (A1)(A0) if not written as an equation.

[2 marks]

(f)  $y = 2.13846\dots \times (8) + 25.1538\dots$  (M1)  
 $y = 42.3$  (42.2615...) (A1)(ft)(G2)

**Notes:** Accept either 42 or 43. (as marks are discrete values).  
Follow through from part (e). Do not award (M1) for finding an estimate by using the graph.  
If the candidate has an incorrect equation in part (e) and there is no attempt to substitute 8 into this equation then (M0)(A0).

[2 marks]

(g) straight line goes through point (their  $\bar{x}$ , their  $\bar{y}$ ) (A1)(ft)  
y-intercept of the straight line is (their) 25.2 (A1)(ft)

**Notes:** Accept  $25.2 \pm 1.5$  for the y-intercept.  
Follow through from parts (d) and (e).  
The line does not need to be labelled.  
The line does not need to intercept the y-axis. However, the extension of their line should intersect the axis at the correct point.  
If graph paper is not used, award at most (A1)(A0).

[2 marks]

(h) not reliable (A1)  
30 marks is outside the given range (R1)

OR

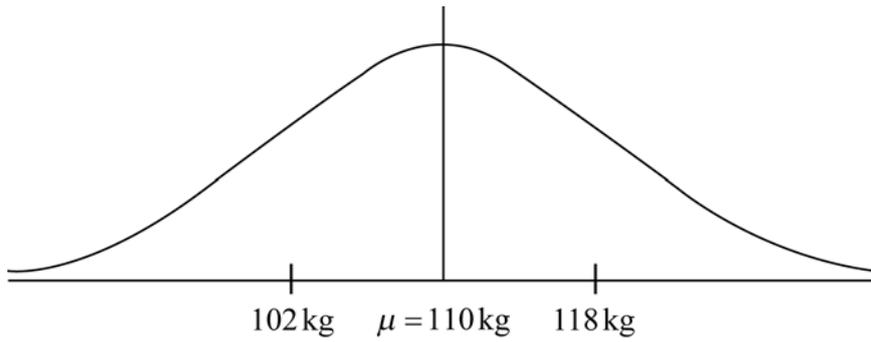
maximum mark of the internal assessment is 20 in the sample (R1)

**Note:** Do not award (A1)(R0).

[2 marks]

Total [19 marks]

3. (a)



(A2)

**Note:** Award (A1) for normal curve with mean of 110 (kg) indicated and (A1) for labelling 118 (kg) (one standard deviation above the mean) and 102 (kg) (one standard deviation below the mean).

[2 marks]

(b) (i) 2

(A1)

**Note:** Do not accept -2.

(ii) 0.977 (0.977249..., 97.7249...%)

(G2)

**Notes:** Do not accept 0.975.  
 Award (G2) for 0.98 unless this comes from 0.975.  
 If (G0), award (M1) for P(weight > 94).  
 If (G0), award (M1) for correct region indicated on a labelled diagram.

[3 marks]

(c) (i) 0.770 (0.770392..., 77.0392...%)

(G2)

**Notes:** If (G0), award (M1) for P(88 < weight < 116).  
 If (G0), award (M1) for correct region indicated on a labelled diagram.

continued...

Question 3 continued

(ii)  $0.770392... \times 160$  (M1)

**Note:** Award (M1) for multiplying their probability from part (c)(i) by 160.

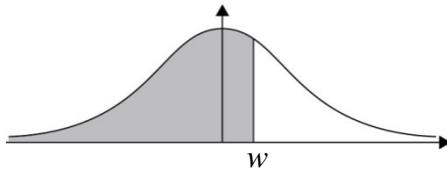
$= 123$  (123.262...) (A1)(ft)(G2)

**Notes:** Accept either 123 or 124 (whole number of sheep).  
Accept 123.2 as the unrounded answer if 0.770 is used.  
Follow through from part (c)(i).

[4 marks]

(d)  $w = 115$  (115.395...) (G2)

**Notes:** If (G0), award (M1) for  $P(\text{weight} < w) = 0.75$ .  
If (G0), award (M1) for a vertical line drawn to the right of the mean with the area to the left of this line shaded. The  $w$  may not be seen.



[2 marks]

(e)  $a = 106$  (105.804...) (G1)

$b = 114$  (114.195...) (G1)

**Note:** If their answers are not identified by the letters  $a$  and  $b$  and the order is incorrect (114 followed by 106) then award, at most, (G0)(G1).

[2 marks]

Total [13 marks]

4. Units are required in part (b) for full marks to be awarded.

(a)  $\cos \hat{BAC} = \frac{140^2 + 120^2 - 110^2}{2(120)(140)}$  (M1)(A1)

**Notes:** Award (M1) for substitution into the cosine rule, (A1) for correct substitution.

$\hat{BAC} = 49.3^\circ$  (49.3236...°) (A1)(G2)  
[3 marks]

(b)  $\frac{1}{2} \times 140 \times 120 \times \sin(\text{their } \hat{BAC})$  (M1)(A1)(ft)

**Note:** Award (M1) for substitution into the area formula, (A1)(ft) for correct substitution.

$= 6370$  (6370.58...) m<sup>2</sup> (A1)(ft)(G2)

**Note:** The answer is 6370 m<sup>2</sup>, the units are **required**. Follow through from part (a). Award (G1) for 6370 given without units and no working.

[3 marks]

(c)  $BDC = 180 - (80 + 40)$  (A1)  
 $= 60^\circ$  (AG)

[1 mark]

(d)  $\frac{DC}{\sin 80^\circ} = \frac{110}{\sin 60^\circ}$  (M1)(A1)

**Note:** Award (M1) for substitution into the sine rule, (A1) for correct substitution.

$DC = 125$  (m) (125.087...) (A1)(G2)  
[3 marks]

continued...

Question 4 continued

(e)  $\frac{DB}{\sin 40^\circ} = \frac{110}{\sin(60^\circ)}$  **(M1)(A1)**

**Note:** Award **(M1)** for substitution into the sine rule, **(A1)** for correct substitution. Accept, as equivalent, the sine rule using  $40^\circ$ ,  $80^\circ$  and  $DC = 125$ , awarding **(M1)(A1)(ft)**. Follow through from part (d).

$DB = 81.6449\dots$  **(A1)(G2)**

**OR**

$DB^2 = (\text{their } DC)^2 + 110^2 - 2(110)(\text{their } DC)\cos 40^\circ$  **(M1)(A1)(ft)**

**Note:** Award **(M1)** for substitution into the cosine rule, **(A1)(ft)** for correct substitution.

$DB = 81.6449\dots$  **(A1)(ft)(G2)**

**Either**  $DB + AB = 221.644\dots$  (m) **or**  $DC + CA = 245.087\dots$  (m) **(A1)(ft)**

**Both**  $DB + AB = 221.644\dots$  (m) **and**  $DC + CA = 245.087\dots$  (m) **(A1)(ft)**

**Notes:** Follow through from part (d).

so the route that passes through B is shorter **(AG)**

**Note:** The final **(A1)(ft)** should only be awarded if the journey lengths are consistent with the demand of the question **and** the conclusion is stated.

**[5 marks]**

**Total [15 marks]**

5. (a) increasing (A1)  
 gradient (of tangent line is) positive (R1)

**Note:** Do not award (A1)(R0).  
 Accept the word 'derivative' for gradient.

[2 marks]

- (b) 150 (A1)

[1 mark]

- (c)  $3nx^2 - 60x - 240$  (A1)(A1)(A1)

**Note:** Award (A1) for each correct term. Award up to (A1)(A1)(A0) if additional terms are seen.

[3 marks]

- (d) (4, -650) (A1)

**Note:** Award (A0) if parentheses are missing. Accept  $x = 4, y = -650$ .

[1 mark]

- (e)  $0 = 3n(4)^2 - 60(4) - 240$  (M1)

**Note:** Award (M1) for the correct substitution of  $x = 4$  or  $x = -2$  into their derivative and equating to zero.

$0 = 48n - 240 - 240$  (A1)(ft)

**Note:** Accept equivalent simplifications. This (A1)(ft) should only be awarded if the final answer of  $n = 10$  is seen following correct simplification. Follow through from part (c).

OR

$-650 = n(4)^3 - 30(4)^2 - 240(4) + 150$  (M1)

**Notes:** Award the (M1) for correct substitution of their (4, -650) into the cubic. Accept other correct coordinates e.g. (-5, -650), (-1, 350) or (5, -550) for the method mark.

$-650 = 64n - 480 - 960 + 150$  (A1)(ft)

**Note:** Accept equivalent simplifications. This (A1)(ft) should only be awarded if the final answer of  $n = 10$  is seen following correct simplification. Follow through from part (d).

$n = 10$  (AG)

**Note:** Substituting  $n = 10$  at the outset invalidates the method, so (M0)(A0).

[2 marks]

continued...

Question 5 continued

(f) (i)  $30(-1)^2 - 60(-1) - 240$  **(M1)**

**Note:** Award **(M1)** for correct substitution into their derivative.

$= -150$  **(A1)(ft)(G2)**

**Note:** Follow through from part (c).

(ii)  $y - 350 = -150(x + 1)$  **OR**  $350 = -150 \times (-1) + c$  **(M1)**

**Note:** Answer must be given as an equation. Award **(M1)** for substituting their gradient from part (f)(i) and the point  $(-1, 350)$ .

$150x + y - 200 = 0$  **(A1)(ft)(G2)**

**Note:** Accept  $-150x - y + 200 = 0$ .  
Do not accept  $y = -150x + 200$ .  
Follow through from their equation  $y - 350 = -150(x + 1)$   
**OR**  $y = -150x + 200$ , correctly rearranged.

(iii)  $\frac{1}{150}$  **(A1)(ft)**

**Note:** Award **(A1)(ft)** for the negative reciprocal of their answer to part (f)(i).

**[5 marks]**

(g) 6.39 (6.38898...) **(G1)**

**Note:** Award **(G0)** if answer is given as coordinates (unless  $x$  is clearly identified).

**[1 mark]**

(h)  $-3.97$  ( $-3.97340\dots$ ) and  $-0.809$  ( $-0.808518\dots$ ) **(G1)(ft)(G1)(ft)**

**Note:** If  $x = 7.78$  ( $7.78192\dots$ ) also seen award at most **(G1)(ft)(G0)**.  
Award, at most, **(G0)(G1)(ft)** if answers given as coordinates, and this was not penalized in part (g). Follow through from part (b).

**[2 marks]**

**Total [17 marks]**

6. (a) volume =  $\pi 4^2 \times 15$  (M1)

**Note:** Award (M1) for correct substitution into volume of a cylinder formula.

= 754 (cm<sup>3</sup>) ((753.982..., 240π)) (A1)(G2)

**Note:** If  $r = 8$  cm is used, then award (M0)(A0) for this part.

[2 marks]

(b)  $85 = \frac{1}{3}\pi(4)^2 \times h$  (M1)

**Notes:** Award (M1) for correct substitution into volume of a cone formula (85 must be seen).  
If  $r = 8$  cm was penalized in part (a), accept  $r = 8$  cm for method here.

( $h =$ ) 5.07 (cm) (5.07306...) (A1)(ft)(G2)

**Notes:** Follow through only for  $r = 8$  cm. Answer is then ( $h =$ ) 1.26826...

[2 marks]

(c) (radius of the hemisphere =) 4.52693... (A1)(ft)

**Notes:** Award (A1)(ft) for 24.6–5.07306...–15. If  $r = 8$  cm used, this value is 8.33173... Follow through from part (b).

( $V =$ )  $\frac{1}{2} \left( \frac{4}{3} \pi (4.52693\dots)^3 \right)$  (A1)(ft)(M1)

**Notes:** Award (A1)(ft) for the correct substitution of their radius of the hemisphere into volume of sphere formula.

Award (M1) for multiplying volume of sphere formula by  $\frac{1}{2}$ .

= 194 (cm<sup>3</sup>) (194.299...) (A1)(ft)(G3)

**Notes:** Accept volume = 195 (cm<sup>3</sup>) from the use of  $r = 4.53$ .  
If  $r = 8$  cm is used, the answer is 1211.33... (cm<sup>3</sup>).  
Follow through from their radius of the hemisphere unless radius = 4 used.  
If radius of hemisphere = 4 cm used, award at most (A0)(A1)(ft)(M1)(A0).

[4 marks]

continued...

Question 6 continued

(d)  $(l = ) \sqrt{5.07306...^2 + 4^2}$  **(M1)**

**Note:** Award **(M1)** for the correct substitution of their part (b) into Pythagoras' theorem.  
If  $r = 8$  cm has been penalized previously, accept  $r = 8$  cm for method here.

curved surface area =  $\pi(4)\sqrt{5.07306...^2 + 4^2}$  **(M1)**

**Note:** Award **(M1)** for correct substitution of their calculated  $l$  into the curved surface area formula. Candidates may have calculated  $l$ , which equals 6.46033...  
Do not accept  $\pi \times 4 \times 5.07306...$  for method.

= 81.1830... **(A1)(ft)**

**Notes:** If  $r = 8$  cm is used, the answer is 203.572...  
Follow through from part (b).

= 81 (cm<sup>2</sup>) **(A1)(ft)(G3)**

**Notes:** The final **(A1)(ft)** is awarded for correctly rounding their 81.1830...

**[4 marks]**

**Total [12 marks]**