2225 – 7309M

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2025

Mathematics: applications and interpretation

Standard level

Paper 1

18 pages

Instructions to Examiners

Abbreviations

M Marks awarded for attempting to use a correct **Method**.

A Marks awarded for an **Answer** or for **Accuracy**; often dependent on preceding ***M*** marks.

R Marks awarded for clear **Reasoning**.

AG Answer given in the question and so no marks are awarded.

FT Follow through. The practice of awarding marks, despite candidate errors in previous parts, for their correct methods/answers using incorrect results.

Using the markscheme

1 General

Award marks using the annotations as noted in the markscheme *eg* ***M1, A2****.*

2 Method and Answer/Accuracy marks

- Do **not** automatically award full marks for a correct answer; all working **must** be checked, and marks awarded according to the markscheme.
- It is generally not possible to award ***M0*** followed by ***A1***, as ***A*** mark(s) depend on the preceding ***M*** mark(s), if any.
- Where ***M*** and ***A*** marks are noted on the same line, *e.g.* ***M1A1***, this usually means ***M1*** for an **attempt** to use an appropriate method (*e.g.* substitution into a formula) and ***A1*** for using the **correct** values.
- Where there are two or more ***A*** marks on the same line, they may be awarded independently; so if the first value is incorrect, but the next two are correct, award ***A0A1A1***.
- Where the markscheme specifies ***A3***, ***M2*** *etc*., do **not** split the marks, unless there is a note.
- The response to a "show that" question does not need to restate the ***AG*** line, unless a **Note** makes this explicit in the markscheme.
- Once a correct answer to a question or part question is seen, ignore further working even if this working is incorrect and/or suggests a misunderstanding of the question. This will encourage a uniform approach to marking, with less examiner discretion. Although some candidates may be advantaged for that specific question item, it is likely that these candidates will lose marks elsewhere too.
- An exception to the previous rule is when an incorrect answer from further working is used **in a subsequent part**. For example, when a correct exact value is followed by an incorrect decimal approximation in the first part and this approximation is then used in the second part. In this situation, award ***FT*** marks as appropriate but do not award the final ***A1*** in the first part.

Examples:

	Correct answer seen	**Further working seen**	**Any FT issues?**	**Action**
1.	$8\sqrt{2}$	5.65685... *(incorrect decimal value)*	No. Last part in question.	Award ***A1*** for the final mark *(condone the incorrect further working)*
2.	$\frac{35}{72}$	0.468111… (incorrect decimal value)	Yes. Value is used in subsequent parts.	Award ***A0*** for the final mark *(and full **FT** is available in subsequent parts)*

3 Implied marks

Implied marks appear in **brackets e.g. *(M1)***,and can only be awarded if **correct** work is seen or implied by subsequent working/answer.

4 Follow through marks (only applied after an error is made)

Follow through (***FT***) marks are awarded where an incorrect answer from one **part** of a question is used correctly in **subsequent** part(s) (e.g. incorrect value from part (a) used in part (d) or incorrect value from part (c)(i) used in part (c)(ii)). Usually, to award ***FT*** marks, **there must be working present** and not just a final answer based on an incorrect answer to a previous part. However, if all the marks awarded in a subsequent part are for the answer or are implied, then ***FT*** marks should be awarded for *their* correct answer, even when working is not present.

For example: following an incorrect answer to part (a) that is used in subsequent parts, where the markscheme for the subsequent part is ***(M1)A1***, it is possible to award full marks for *their* correct answer, **without working being seen.** For longer questions where all but the answer marks are implied this rule applies but may be overwritten by a **Note** in the Markscheme.

- Within a question part, once an **error** is made, no further ***A*** marks can be awarded for work which uses the error, but ***M*** marks may be awarded if appropriate.

- If the question becomes much simpler because of an error then use discretion to award fewer ***FT*** marks, by reflecting on what each mark is for and how that maps to the simplified version.

- If the error leads to an inappropriate value (*e.g.* probability greater than 1, $\sin\theta = 1.5$, non-integer value where integer required), do not award the mark(s) for the final answer(s).

- The markscheme may use the word “their” in a description, to indicate that candidates may be using an incorrect value.

- If the candidate’s answer to the initial question clearly contradicts information given in the question, it is not appropriate to award any ***FT*** marks in the subsequent parts. This includes when candidates fail to complete a “show that” question correctly, and then in subsequent parts use their incorrect answer rather than the given value.

- Exceptions to these ***FT*** rules will be explicitly noted on the markscheme.

- If a candidate makes an error in one part but gets the correct answer(s) to subsequent part(s), award marks as appropriate, unless the command term was “Hence”.

5 Mis-read

If a candidate incorrectly copies values or information from the question, this is a mis-read (***MR***). A candidate should be penalized only once for a particular misread. Use the ***MR*** stamp to indicate that this has been a misread and do not award the first mark, even if this is an ***M*** mark, but award all others as appropriate.

- If the question becomes much simpler because of the ***MR***, then use discretion to award fewer marks.
- If the ***MR*** leads to an inappropriate value (*e.g.* probability greater than 1, $\sin\theta = 1.5$, non-integer value where integer required), do not award the mark(s) for the final answer(s).
- Miscopying of candidates' own work does **not** constitute a misread, it is an error.
- If a candidate uses a correct answer, to a "show that" question, to a higher degree of accuracy than given in the question, this is NOT a misread and full marks may be scored in the subsequent part.
- ***MR*** can only be applied when work is seen. For calculator questions with no working and incorrect answers, examiners should **not** infer that values were read incorrectly.

6 Alternative methods

Candidates will sometimes use methods other than those in the markscheme. Unless the question specifies a method, other correct methods should be marked in line with the markscheme. If the command term is 'Hence' and not 'Hence or otherwise' then alternative methods are not permitted unless covered by a note in the mark scheme.

- Alternative methods for complete questions are indicated by **METHOD 1**, **METHOD 2**, *etc*.
- Alternative solutions for parts of questions are indicated by **EITHER** . . . **OR**.

7 Alternative forms

Unless the question specifies otherwise, **accept** equivalent forms.

- As this is an international examination, accept all alternative forms of **notation** for example 1.9 and 1,9 or 1000 and 1,000 and 1.000.
- Do not accept final answers written using calculator notation. However, ***M*** marks and intermediate ***A*** marks can be scored, when presented using calculator notation, provided the evidence clearly reflects the demand of the mark.
- In the markscheme, equivalent **numerical** and **algebraic** forms will generally be written in brackets immediately following the answer.
- In the markscheme, some **equivalent** answers will generally appear in brackets. Not all equivalent notations/answers/methods will be presented in the markscheme and examiners are asked to apply appropriate discretion to judge if the candidate work is equivalent.

8 Format and accuracy of answers

If the level of accuracy is specified in the question, a mark will be linked to giving the answer to the required accuracy. If the level of accuracy is not stated in the question, the general rule applies to final answers: *unless otherwise stated in the question all numerical answers must be given exactly or correct to three significant figures.*

Where values are used in subsequent parts, the markscheme will generally use the exact value, however candidates may also use the correct answer to 3 sf in subsequent parts. The markscheme will often explicitly include the subsequent values that come "*from the use of 3 sf values*".

Simplification of final answers: Candidates are advised to give final answers using good mathematical form. In general, for an ***A*** mark to be awarded, arithmetic should be completed, and any values that lead to integers should be simplified; for example, $\sqrt{\frac{25}{4}}$ should be written as $\frac{5}{2}$. An exception to this is simplifying fractions, where lowest form is not required (although the numerator and the denominator must be integers); for example, $\frac{10}{4}$ may be left in this form or written as $\frac{5}{2}$. However, $\frac{10}{5}$ should be written as 2, as it simplifies to an integer.

Algebraic expressions should be simplified by completing any operations such as addition and multiplication, e.g. $4e^{2x} \times e^{3x}$ should be simplified to $4e^{5x}$, and $4e^{2x} \times e^{3x} - e^{4x} \times e^{x}$ should be simplified to $3e^{5x}$. Unless specified in the question, expressions do not need to be factorized, nor do factorized expressions need to be expanded, so $x(x+1)$ and $x^2 + x$ are both acceptable.

Please note: intermediate ***A*** marks do NOT need to be simplified.

9 Calculators

A GDC is required for this paper, but if you see work that suggests a candidate has used any calculator not approved for IB DP examinations (eg CAS enabled devices), please follow the procedures for malpractice.

10 Presentation of candidate work

Crossed out work: If a candidate has drawn a line through work on their examination script, or in some other way crossed out their work, do not award any marks for that work unless an explicit note from the candidate indicates that they would like the work to be marked.

More than one solution: Where a candidate offers two or more different answers to the same question, an examiner should only mark the first response unless the candidate indicates otherwise. If the layout of the responses makes it difficult to judge, examiners should apply appropriate discretion to judge which is "first".

1. (a) $(r =)\ 0.999\ (0.998886\ldots)$ ***A2***

[2 marks]

(b) (i) $y = 340x + 742\ \left(y = 340.379\ldots x + 742.015\ldots\right)$ ***A1***

Note: Answer must be written as an equation. If the correct answer is seen here but no marks were awarded in part (a), then award ***A1A0*** for part (a) for accurate GDC data input.

(ii) the (recommended minimum) volume (of the hot air balloon) increases by (approximately) $340\ \text{m}^3$ for each additional passenger ***A1***

[2 marks]

(c) indication of $x = 10$ in regression equation or graph ***(M1)***
e.g. $(y =)\ 340.379\ldots \times 10 + 742.015\ldots$ **OR** graph of regression equation in approximate correct location with $x = 10$ indicated

$4150\ (\text{m}^3)\ \ (4145.81\ldots\ (\text{m}^3))$ ***A1***

[2 marks]

[Total: 6 marks]

2. (a) $(b =)\ 21$ ***A1***

[1 mark]

(b) $(\chi^2_{\text{calc}} =)\ 18.3\ (18.3313\ldots)$ ***A2***

[2 marks]

(c) **EITHER**

$18.3 > 16.81\ (18.3313\ldots > 16.81)$ ***R1***

OR

$(p =)\ 0.00546 < 0.01\ \ (0.00545524\ldots < 0.01)$ ***R1***

Note: The *p*-value $0.00546\ (0.00545524\ldots)$ and the significance level 0.01 or 1% must both be explicitly stated to award ***R1***.

THEN

EITHER

(reject H_0) there is insufficient evidence to suggest that age and car colour preference are independent / not dependent ***A1***

OR

(accept H_1) there is sufficient evidence to suggest that age and car colour preference are not independent ***A1***

Note: The answer to part (c) must be consistent with their χ^2_{calc} in part (b). Do not award ***R0A1***.

[2 marks]

[Total: 5 marks]

3. (a) (i) $x+6y+12z=383$ ***M1A1***

Note: Award ***M1*** for at least one correct term other than x **and** equating to 383, ***A1*** for correct equation.

(ii) $4.50x+23.50y+44.75z=1486$ ***A1***

Note: If no marks were awarded for part (i), award ***M1*** for at least one correct term **and** equating to 1486, ***A1*** for correct equation.

[3 marks]

(b) **EITHER**
attempt to solve the simultaneous equations ***(M1)***
e.g., $(x=)\ 53$ or $(y=)\ 15$ or $(z=)\ 20$

OR
elimination of a variable using algebraic method ***(M1)***

THEN
15 (boxes) ***A1***

Note: The answer 15 must be identified as the final answer to award ***A1***. Award ***M1A0*** if all 3 values are shown as the final answer.

[2 marks]

[Total: 5 marks]

4. (a) (gradient =) $\frac{0.8}{2.7}$ $\left(0.296,\ 0.296296\ldots,\ \frac{8}{27}\right)$ ***A1***

$0.296 < \frac{1}{3}$ $(0.333333\ldots)$ **OR** $\frac{8}{27} < \frac{9}{27}$ ***R1***

the gradient of the pool is less than the gradient in the regulation / the swimming pool satisfies the safety regulation ***AG***

[2 marks]

(b) expressing inverse proportionality using notation or using multiplication to calculate k ***(M1)***

$w \propto \frac{1}{t}$ **OR** $w = \frac{k}{t}$ **OR** $(k =)\ 300 \times 4.5$

$300 \times 4.5 = 170 \times t$ or equivalent ***(A1)***

Note: Accept a calculation in minutes (i.e., $300 \times 270 = 170 \times t$).

$(t =)\ 7.94$ $(7.94117\ldots)$ (h) ***A1***

Note: Award full marks for an answer given in minutes (i.e. 476 $(476.470\ldots)$ minutes or 7 hours and 56 minutes). "Minutes" must be shown as the unit.

[3 marks]

[Total: 5 marks]

5. (a) $d = 5.75 \left(d = \frac{23}{4} \right)$ ***A1A1***

Note: Award ***A1*** for 5.75 seen, ***A1*** for completely correct equation.

[2 marks]

(b) attempt to substitute into the axis of symmetry formula using *their* 5.75 **OR**
attempt to substitute the coordinates $(3, 5.1)$ or $(8.5, 5.1)$ into the function ***(M1)***

$5.75 = \frac{-b}{2\times(-0.2)}$ **OR** $5.1 = -0.2(3)^2 + 3b$ **OR** $5.1 = -0.2(8.5)^2 + 8.5b$

$(b =)\ 2.3$ ***A1***

[2 marks]

(c) indication of finding zero or attempt to use symmetry ***(M1)***
$h(d) = 0$ **OR** $0 = -0.2d^2 + 2.3d$ **OR** 2×5.75 **OR** $3 - 0 = d - 8.5$ **OR**
resketch of graph with zero indicated

$(d =)\ 11.5\ (\text{m})$ ***A1***

Note: Award ***A0*** for a FT answer that is less than 8.5 (contradicts the given information).

[2 marks]

(d) **EITHER**
the dolphin is below the surface of the water / the dolphin is underwater / the dolphin is in the water ***R1***

OR

the value of h cannot be negative since the definition of the model only applies to the jump ***R1***

[1 mark]

[Total: 7 marks]

6. (a) attempt to calculate area of a circle using 4 or 2.8 ***M1***

recognition of multiplication by $\frac{1}{5}$ or $\frac{72}{360}$ ***M1***

$A = \frac{1}{5}\left(\pi(4)^2 - \pi(2.8)^2\right)$

$5.13\ (\text{m}^2)\ (5.12707\ldots\ (\text{m}^2),\ \frac{204\pi}{125}\ (\text{m}^2),\ 1.632\pi\ (\text{m}^2))$ ***A1***

$5.12707\ldots < 6$ **OR** Maureen has enough ***AG***

Note: Do not award the final ***A1*** for the area unless a comparison to 6 is shown OR a statement of having enough is seen.

[3 marks]

(b) $(C =)\ 2\pi(4)\quad (25.1327\ldots)$ ***(A1)***

recognition to multiply by $\frac{3}{5}$ or $\frac{216}{360}$ ***(M1)***

$\frac{3}{5} \times 2\pi(4) + 2 \times 4$

$23.1\ (\text{m})\quad (23.0796\ldots(\text{m}),\ \frac{24\pi}{5} + 8)$ ***A1***

[3 marks]

[Total: 6 marks]

7. (a) Any one of these criteria:
- number of trials/children is fixed (at 5)
- two possible outcomes (for each trial/child with success being brown eyes, failure being not brown eyes)
- the probability of brown eyes/success is constant/the same (for each child/outcome) ***R1***

[1 mark]

(b) (i) $X \sim \mathrm{B}(5,\ 0.75)$

$0.264\ \ (0.263671\ldots)$ ***A2***

(ii) **METHOD 1**

recognizing cumulative probability with a lower bound of 4 ***(M1)***
$\mathrm{P}(X \geq 4)$ **OR** $\mathrm{P}(X > 3)$ **OR** $1 - \mathrm{P}(X \leq 3)$

$0.633\ \ (0.632812\ldots)$ ***A1***

METHOD 2

recognizing a sum of probabilities with a lower bound of 4 ***(M1)***
$\mathrm{P}(X = 4) + \mathrm{P}(X = 5)$ **OR** $0.75^4 \times 0.25 \times 5 + 0.75^5$

$0.633\ \ (0.632812\ldots)$ ***A1***

[4 marks]

[Total: 5 marks]

8. (a) evidence of finding the derivative of $f(x)$ ***(M1)***
e.g., $f'(x)$ seen **OR** attempt to use power rule

$f'(x) = -4x^{-3} - bx^{-2}$ ***(A1)(A1)***

Note: Award ***A1*** for each correct term. Award at most ***(A1)(A0)*** if extra terms are seen.

Substitution of 5 for x and 0.208 for $f'(x)$ in *their* derivative ***(M1)***
$0.208 = -4(5)^{-3} - b(5)^{-2}$

$(b =)\ -6$ ***A1***
[5 marks]

(b) **METHOD 1**
attempt to find the value of the derivative at $x = 3.5$ **OR** $f'(3.5)$ seen ***M1***
$-4(3.5)^{-3} - b(3.5)^{-2}$

$0.397 > 0\ \ (0.396501\ldots > 0)$ **OR** $0.397\ (0.396501\ldots)$ is positive ***R1***

$f(x)$ is increasing at $x = 3.5$ ***AG***

METHOD 2
sketch of derivative with indication of $x = 3.5$ ***M1***

$f'(3.5) > 0$ **OR** $f'(3.5)$ is positive ***R1***

$f(x)$ is increasing at $x = 3.5$ ***AG***
[2 marks]

[Total: 7 marks]

9. (a) $f(x)=0$ seen **OR** sketch of the graph with all three x-intercepts marked **OR** evidence of using product of roots ***(M1)***

$(a=)\ 3$ ***A1***

[2 marks]

(b) evidence of using an integral to find the area ***(M1)***
$\int f(x), \int_1^3$, etc.

(area $=)\ 4$ ***A1***

[2 marks]

[Total: 4 marks]

10. (a) $15p$ ***A1***

[1 mark]

(b) $(p-5)$ or $(n-15)$ seen ***A1***

adding a cost expression (multiplying a p and an n) to their $15p$ ***(M1)***

$C(n)=15p+(p-5)(n-15)$ **OR** $C(n)=np-5n+75$ (or equivalent) ***A1***

[3 marks]

(c) (i) $(25.73\times100=)\ 2573$ (EUR) ***A1***

Note: Answer must be exact.

(ii) correctly substituting *their* total cost and $n=100$ into *their* cost function ***(A1)***
$2573=15p+(p-5)(100-15)$

$(p=)\ 29.98$ (EUR) ***A1***

Note: Answer must be written to 2 dp.

[3 marks]

[Total: 7 marks]

11. (a) $(W =) -34.1 - 7.33\ln(13)$ ***(A1)***

-52.9 $(-52.9010\ldots)$ ***A1***

[2 marks]

(b) attempt to work back from the approximate to the exact value ***(M1)***

$\frac{-52.9010\ldots - v_E}{v_E} = (\pm)0.06$ **OR** $(v_E =) \frac{-52.9010\ldots}{1 \pm 0.06}$ **OR** $v_E(1 \pm 0.06) = -52.9010\ldots$

$-56.3,\ -49.9$ $(-56.2777\ldots,\ -49.9066\ldots)$ ***A1A1***

Note: Award ***A1*** for each correct value.

[3 marks]

[Total: 5 marks]

12. (a) indication of setting the derivative to 0 ***(M1)***

$\frac{\mathrm{d}V}{\mathrm{d}w}=0$ **OR** $690w-36w^2=0$ **OR** sketch of the graph of the derivative with the zero marked

$(w=)$ 19.2 (cm) $(19.1666\ldots$ (cm), $\frac{115}{6}$ (cm)) ***A1***

[2 marks]

(b) evidence of the need to integrate ***(M1)***

integral symbol seen **OR** $\int 690w-36w^2\ \mathrm{d}w$ **OR** one term integrated correctly

$(V=)$ $345w^2-12w^3$ $(+c)$ ***A1***

$c=0$ since $V=0$ when $w=0$ ***R1***

$V=345\times(19.1666\ldots)^2-12\times(19.1666\ldots)^3$

$(V=)$ $42\,246.5\ldots$ (cm^3) **OR** $(V=)$ 42247 (cm^3) seen ***A1***

$42\,200$ cm^3 ***AG***

Note: It is possible to award ***(M1)A1R0A1***. No marks are awarded for part (b) if $42\,200$ is used to work backward.

[4 marks]

(c) **METHOD 1**

attempt to calculate height using volume, width, and length numerical values ***(M1)***

$h=\frac{42\,200}{19.1666\ldots\times(19.1666\ldots\times3)}$ (may be seen in part (b))

$(h=)38.3$ (cm) $(38.2911\ldots$ (cm)) ***(A1)***

Note: Accept a substitution of $42\,246.5\ldots$ for the volume $(h=38.3333\ldots)$.

$19.1666\ldots+57.5+38.2911\ldots$

$(M=)$ 115 $(114.957\ldots)$ (cm) ***A1***

METHOD 2

attempt to calculate height using volume, width, and length expressions ***(M1)***

$h=\frac{345w^2-12w^3}{w\times3w}$

$(h=)$ $115-4w$ ***(A1)***

$w+3w+(115-4w)$

$(M=)$ 115 (cm) ***A1***

[3 marks]

[Total: 9 marks]

13. (a) (i) $170°$ ***(A1)***

(ii) attempt to substitute into the cosine rule formula ***(M1)***

$(DC^2) = 2^2 + 13^2 - 2(2)(13)\cos(170°)$ ***(A1)***

$(DC =)\ 15.0\ (14.9736\ldots)\ (\text{km})$ ***A1***

Note: Do not accept a 2sf answer of 15. Award ***M0A0A0*** for a 2sf answer of 15 with no working shown OR $2+13=15$.

(iii) correct substitution into sine rule or cosine rule ***(A1)***

$\frac{\sin B\hat{D}C}{13} = \frac{\sin 170°}{14.9736\ldots}$ **OR** $\cos(B\hat{D}C) = \frac{14.9736...^2 + 2^2 - 13^2}{2 \times 14.9736... \times 2}$

$(B\hat{D}C =)\ 8.67°\ (8.67097\ldots°)$ ***(A1)***

(bearing $=$) $098.7°\ (098.6709\ldots°)$ ***A1***

[7 marks]

(b) (distance between points D and E $=$) $13\ (\text{km})$ ***A1***

points B, C, D, and E make a parallelogram **OR** DB and EC are parallel **and** equal in length ***R1***

Note: It is possible to award ***A1R0*** for this question part.

[2 marks]
[Total 9 marks]