

Markscheme

May 2026

**Mathematics: applications and
interpretation**

Higher level

Paper 2

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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)

METHOD 1 (use of financial app in GDC)

$$N = 36$$

$$I\% = 2.3$$

$$PV = \pm 14500$$

$$P/Y = 12$$

$$C/Y = 12$$

OR

$$N = 3$$

$$I\% = 2.3$$

$$PV = \pm 14500$$

$$P/Y = 1$$

$$C/Y = 12$$

(M1)(A1)

Note: Award **M1** for evidence of using the financial app on the calculator, **A1** for all correct entries.

$$FV = 15534.80 \text{ GBP}$$

A1

Note: Award at most **(M1)(A1)A0** if correct answer is not given to two decimal places.

METHOD 2 (use of formula)

attempt to substitute into compound interest formula

(M1)

$$14500 \times \left(1 + \frac{2.3}{100 \times 12} \right)^{3 \times 12}$$

(A1)

$$FV = 15534.80 \text{ GBP}$$

A1

Note: Award at most **(M1)(A1)A0** if correct answer is not given to two decimal places.

[3 marks]

continued...

Question 1 continued

$$N = 24$$

$$I\% = 2.3$$

$$(b) \quad PV = \pm 15534.80$$

$$PMT = \pm 250$$

$$P/Y = 12$$

$$C/Y = 12$$

(M1)(A1)

Note: Award **M1** for evidence of using the financial app on the calculator, **A1** for all correct entries, including follow through from their *FV* from part (a).

$$FV = 22399.50 \text{ GBP}$$

A1

Note: Award at most **(M1)(A1)A0** if correct answer is not given to two decimal places unless already penalized in part (a).

[3 marks]

- (c) (i) attempt to use general term of arithmetic sequence with correct substitution of either
 $u_1 = 28492$ or $d = -1876$ (M1)

$$u_n = 28492 + (n-1)(-1876)$$

$$u_n = 30368 - 1876n$$

A1

- (ii) attempt to substitute $n = 7$ into their formula (M1)

$$17236 \text{ GBP}$$

A1

Note: The sequence is decreasing, so $u_7 < 28492$. If a candidate's sequence from part (c)(i) is increasing, award at most **(M1)A0** for part (c)(ii). Their result contradicts the context of the question.

continued...

Question 1 continued

- (iii) Award **R1** for a valid mathematical or contextual limitation of the model

R1

Mathematical

- restricted to integer values of n
- the model can give a negative cost (for cars older than 16 years)
- may not be a linear model

Contextual

- (vehicles of the same age) may vary in condition eg mileage, service history...
- the formula may not apply to all cars with the same age
- cost > 0 (a vehicle will always retain some value as scrap metal or parts)
- age alone may not determine the cost
- does not factor inflation (non-linear)

Note: Award **R0** for only stating “condition of the car” or only “mileage” or similar. These reasons support the formula and might already be factored into the formula. These answers do not communicate the cost may vary for the same value of n .

[5 marks]

- (d) valid approach to find cost of used car

(M1)

setting $u_n = 22399.50$ to find n OR continuing the sequence to beyond 22399.50

cost of used car = 20988

(A1)

amount remaining = 1411.50 GBP

A1

Note: Award at most **(M1)(A1)A0** if correct answer is not given to two decimal places unless already penalized in parts (a) or (b).

[3 marks]

Total [14 marks]

2 (a) attempt to divide 360 or 2π by 24 (M1)

15 OR $\frac{\pi}{12}$ OR $\frac{2\pi}{24}$ OR 0.262 (0.261799...) A1

[2 marks]

(b) (i) $36.9 = a \sin(15 \times 18) + c$ OR $36.9 = a \sin(270) + c$ OR $36.9 = a \sin\left(\frac{\pi}{12} \times 18\right) + c$ A1

$36.9 = -a + c$ AG

(ii) attempt to substitute $t = 13$, $T = 36.6$ into their equation (M1)

$36.6 = a \sin(15 \times 13) + c$ OR $36.6 = a \sin(195) + c$ OR $36.6 = a \sin\left(\frac{\pi}{12} \times 13\right) + c$ A1

OR $36.6 = -0.258819...a + c$ ($36.6 = -0.259a + c$)

(iii) attempt to solve the two equations (M1)

$a = -0.405$ ($-0.404759...$) A1

$c = 36.5$ ($36.4952...$) A1

[6 marks]

(c) $T = 36.1$ ($36.1447...$) A1

$36.2 > 36.1$, hence above the curve R1

Note: Do not award **A0R1**.

[2 marks]

(d) 00:00 to 06:00 and 18:00 to 24:00 A1A1

Note: Award **A1** for each correct interval in a 24-hour cycle.

Accept intervals of t , for example $0 < t < 6$ and $18 < t < 24$.

[2 marks]

Total [12 marks]

- 3 (a) attempt to substitute r and v into formula (M1)

$$P = 0.245 \pi (40)^2 (10)^3$$

$$= 1231504.32 \quad (A1)$$

$$= 1.23 \times 10^6 \quad A1$$

Note: The final **A1** is for correctly converting their answer for P into standard form.

[3 marks]

- (b) (i) 10.75 seen A1

$$P = 0.245 \pi (40)^2 (10.75)^3$$

$$1529893.96... \quad A1$$

$$1.53 \times 10^6 \quad AG$$

- (ii) 13.85 seen to find upper bound of P (A1)

$$P_{\max} = 3271788.78...$$

attempt to find difference between their maximum and minimum power (M1)

$$1.74 \times 10^6 \quad (1.74189... \times 10^6) \quad A1$$

Note: Accept 1740000.

[5 marks]

continued...

Question 3 continued

- (c) (i) correct use of the power rule for at least 2 terms **M1**

$$\left(\frac{dP}{dv} = \right) 17.92v^3 - 708v^2 + 7140v - 8740 \quad \text{A1A1}$$

- (ii) use of graph of $\frac{dP}{dv}$ OR use of graph of P OR solve cubic equation (GDC solver, algebraic rearrangement, numerical trial, or stating a root) **(M1)**

$$v = 14.8 \text{ (ms}^{-1}\text{)} \text{ (14.7728....)} \quad \text{A1}$$

Note: Do not award **A1** if their answer, including any **FT** answer, is outside the domain $3.35 \leq v < 17.15$.

- (iii) this is the value of v which produces maximum power **A1**

[6 marks]

- (d) set $P = 90000$ **(M1)**

$$90000 = 4.48v^4 - 236v^3 + 3570v^2 - 8740v - 735$$

$$v = 11.4550...$$

$$11.46 \leq v < 17.15 \quad \text{A1A1}$$

Note: Award **A1** for each correct endpoint in the correct form expressed as an interval with two endpoints. The **A1** for 17.15 is independent of the **M1**.

[3 marks]

Total [17 marks]

- 4 (a) (i) $P(A < 14) = 0.462$ (0.462062...) **A2**
- (ii) $(0.462062...)^3$ OR use of $B(3, 0.462062...)$ **(M1)**
- 0.0987 (0.0986513...) **A1**

Note: Accept 0.0986 from use of 0.462.

[4 marks]

- (b) times in each race are independent of any previous race **A1**
- [1 mark]**

- (c) attempt to compare with Sofia's time $P(A > 13.2)$ **(M1)**
- $= 0.683$ (0.683030...) **A1**

Note: Award **(M1)A0** for $P(A < 13.2) = 0.317$ (0.31697...).

[2 marks]

- (d) Sofia completes the race in a shorter time than Anne **A1**

Note: Accept equivalent expressions for example "Sofia beats Anne" OR "Anne completes the race in a longer time than Sofia".

[1 mark]

- (e) (i) $E(D) = 0.8$ minutes **A1**
- (ii) $\text{Var}(D) = 2.1^2 + 1.7^2$ **(A1)**

7.3 minutes² **A1**

[3 marks]

- (f) $P(D < 0)$ using their $D \sim N(0.8, 7.3)$ **(M1)**
- 0.384 (0.383579...) **A1**

Note: Award **(M1)A0** for 0.616 (0.616421...).

[2 marks]

Total [13 marks]

- 5** (a) (i) repeating edge AB (M1)
- $$122 + \frac{1}{2} \times 8$$
- 126 A1
- (ii) for example
ABDEFGEHCBAHIA A1
- [3 marks]
- (b) (i) vertices of odd degree are A, B, C, D (A1)
- consideration of the weights of at least two pairings M1
- pairings are
- AB and CD, $8 + 14 = 22$
- AC and BD, $15 + 18 = 33$
- AD and BC, $26 + 7 = 33$ A1
- (need to repeat) AB and CD A1
- (ii) adding edge CD (14) + $\frac{1}{2}$ of their repeated edges to the total sum (M1)
- $$122 + 14 + \frac{1}{2} \times 22 \quad \text{OR} \quad 126 + 14 + 7$$
- 147 minutes A1
- [6 marks]
- (c) (i) choice of pair containing edge of least weight (M1)
- dropped at A and picked up at D or vice versa A1
- (ii) time saved $\left(= \frac{1}{2} \times (22 - 7) = \right) 7.5$ minutes A1
- [3 marks]
- Total [12 marks]**

- 6 (a) (i) $a^2 + 10^2 = 26^2$ (M1)
 $a = 24$ A1
- (ii) $\arctan\left(\frac{10}{24}\right)$ (M1)
 $22.6198\dots^\circ, (0.394791\dots)$ (A1)
bearing = 113° ($112.619\dots^\circ$) A1

Note: Award (M1)(A1)A0 for 1.97 radians (1.96558...).

[5 marks]

- (b) attempt to find coordinates using vectors or a diagram (M1)
- $$\mathbf{r} = \begin{pmatrix} 5 \\ 20 \end{pmatrix} + 3 \begin{pmatrix} 24 \\ -10 \end{pmatrix}$$
- (77, -10) A1

Note: Condone $x = 77, y = -10$ and column vector $\begin{pmatrix} 77 \\ -10 \end{pmatrix}$.

[2 marks]

- (c) **METHOD 1**
- coordinates of P (129, -10) (A1)
- use of distance formula (M1)
- $$d = \sqrt{(129 - 5)^2 + (20 - (-10))^2}$$
- $d = 128$ km (127.577...) A1
- METHOD 2**
- angle $180 - 22.6198\dots = 157.380\dots$ (A1)
- use of cosine rule (M1)
- $$d^2 = 78^2 + 52^2 - 2 \times 78 \times 52 \cos(157.380\dots)$$
- $d = 128$ km (127.577...) A1

[3 marks]

continued...

Question 6 continued

- (d) time taken = $\left(\frac{127.577...}{40}\right) = 3.18943...$ **A1**
- $13 - 3.18943... (= 9.81056...)$ **M1**
- 09:49 **A1**

Note: Accept 09:48 if rounded value for distance used, then time taken is 3.2, so
 $13 - 3.2 = 9.8$ hours or 9:48

[3 marks]

Total [13 marks]

7 (a) (i) attempt to multiply the matrices (M1)

$$\begin{pmatrix} a^2 & 2a+2 \\ 0 & 1 \end{pmatrix} \quad \text{A1}$$

(ii) $\begin{pmatrix} a^3 & 2a^2+2a+2 \\ 0 & 1 \end{pmatrix}$ A1

[3 marks]

(b) $\det A = a$ OR $\det A^3 = a^3$ (A1)

use of determinant formula for area M1

$$16a^3 = 2 \text{ or equivalent} \quad \text{A1}$$

$$a = 0.5 \quad \text{AG}$$

[3 marks]

(c) (i) 0.5^n A1

Note: Condone a^n .

(ii) recognition of a geometric series M1

$$\frac{2(1-a^n)}{1-a}$$

$$\frac{2(1-0.5^n)}{1-0.5} \quad \text{A1}$$

$$q_n = 4(1-0.5^n) \quad \text{AG}$$

[3 marks]

continued...

Question 7 continued

(d) **METHOD 1**

$$\begin{pmatrix} 0.5^n & 4(1-0.5^n) \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 128 \\ 96 \end{pmatrix} = \begin{pmatrix} 383.75 \\ 96 \end{pmatrix} \quad (M1)$$

$$0.5^n \times 128 + 4(1-0.5^n) \times (96) = 383.75 \quad (M1)$$

$$n = 10 \quad A1$$

METHOD 2

$$\text{recognition that } A^n = (A)^n \quad (M1)$$

$$\begin{pmatrix} 0.5 & 2 \\ 0 & 1 \end{pmatrix}^n \begin{pmatrix} 128 \\ 96 \end{pmatrix} = \begin{pmatrix} 383.75 \\ 96 \end{pmatrix} \quad (M1)$$

$$n = 10 \quad A1$$

[3 marks]

Total [12 marks]

- 8 (a) recognition that $\frac{dV}{dt} = kh$ (M1)
- use of given values to find k (M1)
- $-0.4 = k \times 0.5$

Note: Condone lack of minus sign for the method marks.

$$k = -0.8$$

$$\frac{dV}{dt} = -0.8h$$

A1

[3 marks]

(b) $\frac{dV}{dt} = 2.0 - 0.8h$

A1

$$V = 16h \text{ OR } \frac{dV}{dh} = 16$$

A1

use of the chain rule

(M1)

$$\frac{dh}{dt} = \frac{dV}{dt} \div \frac{dV}{dh} \text{ OR } \frac{dh}{dt} = \frac{dh}{dV} \times \frac{dV}{dt} \text{ OR } \frac{dv}{dt} = 16 \frac{dh}{dt}$$

$$\frac{dh}{dt} = \frac{2.0 - 0.8h}{16}$$

A1

$$\frac{dh}{dt} = 0.125 - 0.05h$$

AG

[4 marks]

continued...

Question 8 continued

(c) $\frac{dh}{dt} = 0.125 - 0.05h$

attempt to separate variables

M1

$$\int \frac{1}{0.125 - 0.05h} dh = \int 1 dt$$

recognition that LHS contains ln of a linear function

M1

$$-\frac{1}{0.05} \ln|0.125 - 0.05h| = t (+c)$$

A1A1

Note: Award **A1** for correct RHS and **A1** for correct LHS (as the original height is less than 2.5 m the modulus is not needed).

Accept equivalent forms eg $-20 \ln|2.5 - h| = t (+c)$.

taking the exponent of each side

M1

$$0.125 - 0.05h = Ae^{-0.05t}$$

$$h = \frac{0.125 - Ae^{-0.05t}}{0.05}$$

$$h = 2.5 - Be^{-0.05t}$$

substituting the given point

M1

when $t = 5, h = 0.5$

$$0.5 = 2.5 - Be^{-0.05 \times 5}$$

$$B = 2.57 \quad (2.56805... = 2\sqrt[4]{e})$$

A1

$$h = 2.5 - 2.57e^{-0.05t}$$

A1

Note: Accept equivalent forms with h as the subject eg $h = 2.5 - e^{-0.05t+0.943}$.

[8 marks]

(d) the height of the water increases

A1

to a limit of $h = 2.5$

A1

[2 marks]

Total [17 marks]