GCE

Mathematics B MEI

H640/02: Pure Mathematics and Statistics

A Level

Mark Scheme for June 2025

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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MARKING INSTRUCTIONS

PREPARATION FOR MARKING
RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training: OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are available in RM Assessor

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 40% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the RM Assessor messaging system.

5. **Crossed-Out Responses**
   Where a candidate has crossed out a response and provided a clear alternative then the crossed-out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed-out response where legible.

Rubric Error Responses – Optional Questions
Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM Assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple-Choice Question Responses
When a multiple-choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).
When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses
When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only one mark per response)
Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth two or more marks)
If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space).

Longer Answer Questions (requiring a developed response)
Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there, then add the annotation 'SEEN' to confirm that the work has been seen and mark any responses using the annotations in section 11.

7. There is a NR (**No Response**) option. Award NR (No Response):

   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in any way relate to the question (e.g., 'can't do', 'don't know')
   - OR if there is a mark (e.g., a dash, a question mark) which is not an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The RM Assessor **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response: Not applicable in F501
    To determine the level – start at the highest level and work down until you reach the level that matches the answer
    To determine the mark within the level, consider the following

Descriptor	Award mark
On the borderline of this level and the one below	At bottom of level
Just enough achievement on balance for this level	Above bottom and either below middle or at middle of level (depending on number of marks available)
Meets the criteria but with some slight inconsistency	Above middle and either below top of level or at middle of level (depending on number of marks available)
Consistently meets the criteria for this level	At top of level

11. **Annotations**

Annotation	Meaning
✓and ✗	
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working
M0, M1	Method mark awarded 0, 1
A0, A1	Accuracy mark awarded 0, 1
B0, B1	Independent mark awarded 0, 1
SC	Special case
^	Omission sign
MR	Misread
BP	Blank Page
Seen	
Highlighting	

Other abbreviations in mark scheme	Meaning
dep*	Mark dependent on a previous mark, indicated by *. The * may be omitted if only one previous M mark
cao	Correct answer only
oe	Or equivalent
rot	Rounded or truncated
soi	Seen or implied
www	Without wrong working
AG	Answer given
awrt	Anything which rounds to
BC	By Calculator
DR	This question included the instruction: In this question you must show detailed reasoning.

Subject Specific Marking Instructions

a. Annotations must be used during your marking. For a response awarded zero (or full) marks a single appropriate annotation (cross, tick, M0 or ^) is sufficient, but not required.

For responses that are not awarded either 0 or full marks, you must make it clear how you have arrived at the mark you have awarded and all responses must have enough annotation for a reviewer to decide if the mark awarded is correct without having to mark it independently.

It is vital that you annotate standardisation scripts fully to show how the marks have been awarded.

Award NR (No Response)
- if there is nothing written at all in the answer space and no attempt elsewhere in the script
- OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
- OR if there is a mark (e.g. a dash, a question mark, a picture) which isn't an attempt at the question.

Note: Award 0 marks only for an attempt that earns no credit (including copying out the question).

If a candidate uses the answer space for one question to answer another, for example using the space for 8(b) to answer 8(a), then give benefit of doubt unless it is ambiguous for which part it is intended.

b. An element of professional judgement is required in the marking of any written paper. Remember that the mark scheme is designed to assist in marking incorrect solutions. Correct solutions leading to correct answers are awarded full marks but work must not always be judged on the answer alone, and answers that are given in the question, especially, must be validly obtained; key steps in the working must always be looked at and anything unfamiliar must be investigated thoroughly. Correct but unfamiliar or unexpected methods are often signalled by a correct result following an apparently incorrect method. Such work must be carefully assessed. When a candidate adopts a method which does not correspond to the mark scheme, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.

If you are in any doubt whatsoever you should contact your Team Leader.

c. The following types of marks are available.

M
A suitable method has been selected and applied in a manner which shows that the method is essentially understood. Method marks are not usually lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. In some cases the nature of the errors allowed for the award of an M mark may be specified.
A method mark may usually be implied by a correct answer unless the question includes the DR statement, the command words “Determine” or “Show that”, or some other indication that the method must be given explicitly.

A
Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated Method mark is earned (or implied). Therefore M0 A1 cannot ever be awarded.

B
Mark for a correct result or statement independent of Method marks.

Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored. Sometimes this is reinforced in the mark scheme by the abbreviation isw. However, this would not apply to a case where a candidate passes through the correct answer as part of a wrong argument.

d. When a part of a question has two or more ‘method’ steps, the M marks are in principle independent unless the scheme specifically says otherwise; and similarly where there are several B marks allocated. (The notation ‘dep*’ is used to indicate that a particular mark is dependent on an earlier, asterisked, mark in the scheme.) Of course, in practice it may happen that when a candidate has once gone wrong in a part of a question, the work from there on is worthless so that no more marks can sensibly be given. On the other hand, when two or more steps are successfully run together by the candidate, the earlier marks are implied and full credit must be given.

e. The abbreviation FT implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A and B marks are given for correct work only – differences in notation are of course permitted. A (accuracy) marks are not given for answers obtained from incorrect working. When A or B marks are awarded for work at an intermediate stage of a solution, there may be various alternatives that are equally acceptable. In such cases, what is acceptable will be detailed in the mark scheme. If this is not the case please, escalate the question to your Team Leader who will decide on a course of action with the Principal Examiner.

Sometimes the answer to one part of a question is used in a later part of the same question. In this case, A marks will often be ‘follow through’. In such cases you must ensure that you refer back to the answer of the previous part question even if this is not shown within the image zone. You may find it easier to mark follow through questions candidate-by-candidate rather than question-by-question.

f. Unless units are specifically requested, there is no penalty for wrong or missing units as long as the answer is numerically correct and expressed either in SI or in the units of the question. (e.g. lengths will be assumed to be in metres unless in a particular question all the lengths are in km, when this would be assumed to be the unspecified unit.)
We are usually quite flexible about the accuracy to which the final answer is expressed; over-specification is usually only penalised where the scheme explicitly says so.
- When a value is given in the paper only accept an answer correct to at least as many significant figures as the given value.
- When a value is not given in the paper accept any answer that agrees with the correct value to 2 s.f. unless a different level of accuracy has been asked for in the question, or the mark scheme specifies an acceptable range.
  NB for Specification A the rubric specifies 3 s.f. as standard, so this statement reads “3 s.f”.

Follow through should be used so that only one mark in any question is lost for each distinct accuracy error.
Candidates using a value of 9.80, 9.81 or 10 for g should usually be penalised for any final accuracy marks which do not agree to the value found with 9.8 which is given in the rubric.

g. Rules for replaced work and multiple attempts:
- If one attempt is clearly indicated as the one to mark, or only one is left uncrossed out, then mark that attempt and ignore the others.
- If more than one attempt is left not crossed out, then mark the last attempt unless it only repeats part of the first attempt or is substantially less complete.
- if a candidate crosses out all of their attempts, the assessor should attempt to mark the crossed out answer(s) as above and award marks appropriately.

h. For a genuine misreading (of numbers or symbols) which is such that the object and the difficulty of the question remain unaltered, mark according to the scheme but following through from the candidate’s data. A penalty is then applied; 1 mark is generally appropriate, though this may differ for some units. This is achieved by withholding one A or B mark in the question. Marks designated as cao may be awarded as long as there are no other errors.
If a candidate corrects the misread in a later part, do not continue to follow through. Note that a miscopy of the candidate’s own working is not a misread but an accuracy error.

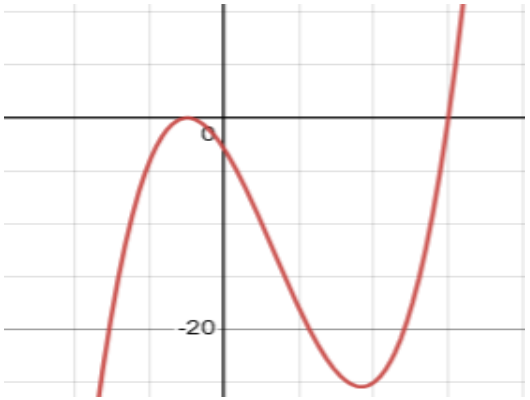
i. If a calculator is used, some answers may be obtained with little or no working visible. Allow full marks for correct answers, provided that there is nothing in the wording of the question specifying that analytical methods are required such as the bold “In this question you must show detailed reasoning”, or the command words “Show” or “Determine”. Where an answer is wrong but there is some evidence of method, allow appropriate method marks. Wrong answers with no supporting method score zero. If in doubt, consult your Team Leader.

j. If in any case the scheme operates with considerable unfairness consult your Team Leader.

Question		Answer	Marks	AO	Guidance
1	(a)	[centre is] (4, – 5)	B1 [1]	1.1	allow $x = 4, y = -5$; condone omission of brackets
1	(b)	[radius is] 8	B1 [1]	1.1	

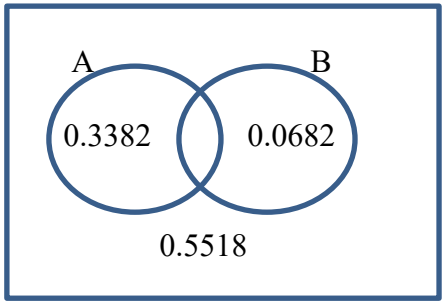
Question		Answer	Marks	AO	Guidance
2		${}_{12}C_3$ or ${}_{12}C_9$ or 220 or $\frac{12!}{3!9!}$ **oe** seen 1760	M1 A1 [2]	2.1 1.1	may be embedded eg ${}_{12}C_3\,(2x)^3$; if **M0** allow **SCB1** for 1760 seen; **A0** for final answer of $1760x^3$

Question		Answer	Marks	AO	Guidance
3		cos CAB = $\frac{4.7^2+6.9^2-11.2^2}{2\times4.7\times6.9}$ **oe soi** 2.60 or 149 **cao**	M1 A1 [2]	1.1a 1.1	may be implied by correct answer to 3 or more significant figures may see $\frac{-55.74}{64.86}$ or –0.859(389…) **NB** 2.60487074…or 149.2480998.. must be to 3 s.f. ; ignore incorrect units

Question		Answer	Marks	AO	Guidance
4	(a)	$4 \times 3^3 - 8 \times 3^2 - 11 \times 3 - 3$ $[= 108 - 72 - 33 - 3] = 0$	B1 [1]	1.1	arithmetic must be correct and 4 terms must be seen
4	(b)	$(4x^2 + 4x + 1)$ seen $(x-3)(2x+1)^2$ **isw** or $a = 2$, $b = 1$ **isw**	M1 A1	2.1 1.1	may be embedded in long/synthetic division; allow one coefficient error allow $(x-3)(2x+1)(2x+1)$; mark the final answer; supporting working must be seen for the award of this mark
		Alternative method $a^2 = 4,\ -3a^2 + 2ab = -8,$ $b^2 - 6ab = -11, -3b^2 = -3$ $a = 2, b = 1$ **isw**	M1 A1		for any two equations from equating coefficients; may be embedded in expansion; allow one coefficient error supporting working must be seen for the award of this mark
			[2]		
4	(c)		M1 A1 [2]	1.1 1.1	cubic of correct orientation; curve touches x-axis on correct side of origin for their $-\frac{b}{a}$ and intersects positive x-axis; intercepts at $\left(-\frac{1}{2}, 0\right)$, $(3, 0)$ and $(0, -3)$ labelled or identified on sketch; local minimum in 4th quadrant

Question		Answer	Marks	AO	Guidance
5		$1 + 3 + 5 + \ldots + (2n \pm 1)$	M1	2.1	or identify AP with n terms and $a = 1$, $d = 2$; may be implied by award of first **A1**
		$\frac{n}{2}(2 \times 1 + (n-1) \times 2)$ **or** $\frac{n}{2}(1 + (2n-1))$	A1	1.1	use of formula for sum of arithmetic progression with n terms and $a = 1$ and $l = 2n - 1$; **or** $a = 1$ and $d = 2$; allow $\frac{n}{2}(2 + 2n - 2)$ but no further contraction
		$\frac{n}{2} \times 2n = n^2$ [which is a square number]	A1	2.2a	correct intermediate step needed for **A1**
		Alternative method (Further Maths 1)			
		$2\sum_{r=1}^{n} r - n$	M1		from $\sum_{r=1}^{n}(2r-1)$; allow for $\sum_{r=1}^{n}(2r+1)$; may be implied by award of first **A1**
		$=2 \times \frac{n(n+1)}{2} - n$	A1		all correct;
		$n^2 + n - n = n^2$ [which is a square number]	A1		correct intermediate step needed for **A1**
		Alternative method (Further Maths 2)			
		assume $\sum_{r=1}^{k}(2r-1) = k^2$ (i) working towards $\sum_{r=1}^{k+1}(2r-1) = (k+1)^2$ (ii)	M1		
		$\sum_{r=1}^{k}(2r-1) + (2(k+1)-1)$ $= k^2 + 2k + 1$ $= (k+1)^2$ so true for $n = k + 1$ if true for $n = k$	A1		correct intermediate step **and** statement needed
		$2 \times 1 - 1 = 1^2$ so true for $n = 1$ so by induction true for $n = 2, 3, 4, \ldots$	A1		
			[3]		

Question		Answer	Marks	AO	Guidance
6	(a)	$y = \sin 2x$ or $\frac{1}{\mathrm{f}(x)} = \sin 2x$	B1 [1]	1.2	**cao**
6	(b)	$x = 0, x = \frac{\pi}{2}, x = \pi,$ **isw**	B1 [1]	1.1	all correct; ignore equations outside the range, **B0** if extra equations in the range **B0** for $x = 0, \frac{\pi}{2}, \pi$; **B0** for $y = \ldots$

Question		Answer	Marks	AO	Guidance
7	(a)		B1 B1 [2]	1.1 1.1	2 probabilities correctly placed all three correctly placed; ignore other values
7	(b)	[P(A ∩ B) =]1 − 0.5518 − 0.3382 − 0.0682 P(A) = 0.3382 + their 0.0418 **or** P(B) = 0.0682 + their 0.0418 [P(A) =]0.38 and [P(B) =] 0.11 $0.38 \times 0.11 = 0.0418$ so [A and B are] **independent**	M1 M1 A1 A1	3.1a 2.1 1.1 3.2a	value for P(A ∩ B) found; allow M1 for 0.0418 unsupported; allow if seen in part (a) on diagram and nowhere else may be implied by 0.38 or 0.11 even if wrongly attributed both correct; allow unsimplified allow (0.3382 + 0.0418)× (0.0682 + 0.0418) ; allow P(A)× P(B) = 0.0418 if P(A) = 0.38 and P(B) = 0.11 seen elsewhere
		Alternative method [P(A ∩ B) =]1 − 0.5518 − 0.3382 − 0.0682 P(B) = 0.0682 + their 0.0418 **or** P(A) = 0.3382 + their 0.0418 $P(A\|B) = \frac{0.0418}{(0.0682 + 0.0418)} = 0.38$ $P(A\|B) = 0.38 = P(A)$ so **independent**	M1 M1 A1 A1		value for P(A ∩ B) found; allow M1 for 0.0418 unsupported allow if seen in part (a) on diagram may be implied by 0.11 **or** may be implied by 0.38 **or** $P(B\|A) = \frac{0.0418}{(0.3382 + 0.0418)} = 0.11$; allow eg $P(A\|B) = \frac{P(A \cap B)}{P(B)} = 0.38$ if P(B) = 0.11 and $P(A \cap B) = 0.0418$ seen elsewhere **or** $P(B\|A) = 0.11 = P(B)$ so independent
			[4]		

Question		Answer	Marks	AO	Guidance
7	(c)	$\mathrm{P}(\mathrm{A} \cap \mathrm{B}) \neq 0$ so not mutually exclusive **or** $1 - 0.5518 \neq$ their $0.11 +$their 0.38 so $\mathrm{P}(A \cup B) \neq \mathrm{P}(A) + \mathrm{P}(B)$ so not mutually exclusive	**B1** **[1]**	**2.4**	allow $\mathrm{P}(\mathrm{A} \cap \mathrm{B}) =$ their 0.0418 so not mutually exclusive; must refer to probability; do **not** allow eg they have an intersection; eg the intersection is 0.0418

Question		Answer	Marks	AO	Guidance
8	(a)	eg horizontal line at cf = 90 or 91; eg curve marked at cf = 90 or 91 and mark stated eg vertical axis marked at 90 or 91 and mark stated eg horizontal axis marked between 60 and 65 and mark stated 62, 63 or 64	**M1** **A1** **[2]**	**1.1** **1.1**	allow if seen on diagram for part (b) if **M0** allow **B1** for 62, 63 or 64
8	(b)	eg vertical line from mark = 75 eg curve marked at x = 75 and cf stated eg horizontal axis marked at 75 and cf stated eg vertical axis marked at 104 – 106 and cf stated 14, 15 or 16	**M1** **A1** **[2]**	**1.1** **1.1**	allow if seen on diagram for part (a) if **M0** allow **B1** for 14, 15 or 16

Question		Answer	Marks	AO	Guidance
9	(a)	$\begin{pmatrix}3\\3\\-3\end{pmatrix}$ **or** $3\mathbf{i}+3\mathbf{j}-3\mathbf{k}$	B1 [1]	1.1	do not allow (3, 3, −3); mark the final answer
9	(b)	$[\overrightarrow{OC}=]\begin{pmatrix}-1\\-2\\0\end{pmatrix}+\frac{1}{3}\begin{pmatrix}3\\3\\-3\end{pmatrix}$ **oe** $\begin{pmatrix}0\\-1\\-1\end{pmatrix}$ **or** $-\mathbf{j}-\mathbf{k}$	M1 A1	3.1a 1.1	**FT** their $\begin{pmatrix}3\\3\\-3\end{pmatrix}$ allow **B2** for correct answer unsupported; mark the final answer if **M0** allow **SC1** for $\left[\begin{pmatrix}-1\\-2\\0\end{pmatrix}+\frac{2}{3}\begin{pmatrix}3\\3\\-3\end{pmatrix}=\right]\begin{pmatrix}1\\0\\-2\end{pmatrix}$ do not allow (0, −1, −1); only penalise coordinate form once
		Alternative method 1 $[\overrightarrow{AC}=]\begin{pmatrix}a--1\\b--2\\c-0\end{pmatrix}$ $[\overrightarrow{CB}=]\begin{pmatrix}2-a\\1-b\\-3-c\end{pmatrix}$ $2\overrightarrow{AC}=\overrightarrow{CB}$ equating coefficients: $2a+2=2-a$ $2b+4=1-b$ $2c=-3-c$ $\begin{pmatrix}0\\-1\\-1\end{pmatrix}$ **or** $-\mathbf{j}-\mathbf{k}$	 M1 A1		may work with **i, j, k** notation allow one sign error only do not allow (0, −1, −1); only penalise coordinate form once

Question		Answer	Marks	AO	Guidance
		Alternative method 2 $2\overrightarrow{OC} - 2\begin{pmatrix}-1\\-2\\0\end{pmatrix} = \begin{pmatrix}2\\1\\-3\end{pmatrix} - \overrightarrow{OC}$ $\begin{pmatrix}0\\-1\\-1\end{pmatrix}$ **or** $-\mathbf{j} - \mathbf{k}$	**M1** **A1**		may see $3\overrightarrow{OC} = \begin{pmatrix}0\\-3\\-3\end{pmatrix}$; allow one sign error only; may work with **i, j, k** notation do not allow (0, −1, −1); only penalise coordinate form once
		Alternative method 3 $[\overrightarrow{OC} =]\frac{2}{3}\begin{pmatrix}-1\\-2\\0\end{pmatrix} + \frac{1}{3}\begin{pmatrix}2\\1\\-3\end{pmatrix}$ $\begin{pmatrix}0\\-1\\-1\end{pmatrix}$ **or** $-\mathbf{j} - \mathbf{k}$	**M1** **A1**		ratio theorem; may work with **i, j, k** notation do not allow (0, −1, −1); only penalise coordinate form once
			[2]		

Question		Answer	Marks	AO	Guidance
10	(a)	53.125 rounded to 2 or more sf **isw**	**B1** **[1]**	**1.1**	
10	(b)	**likely** to be close because **oe** allow eg linear model seems appropriate eg interpolation eg 1975 is within range eg points are approximately in a straight line	**B1** **[1]**	**2.2b**	allow eg yes do **not** allow eg 53.125 is within range eg positive correlation eg follows the same trend eg the **value for** 1975 is between the **values for** 1970 and 1980
10	(c)	**not likely** to be close approximation because **oe** eg **life expectancy** generally **higher** in UK (or Europe) **oe** eg **life expectancy** generally **lower** in Sudan (or Africa) **oe** eg **change** of life expectancy **over time different** in UK **oe**	**B1** **[1]**	**2.4**	must refer to life expectancy; must refer to UK or Europe **or** Sudan or Africa; ignore superfluous speculation do not allow eg not likely to be close because data is different eg life expectancy varies between countries
10	(d)	remove / delete the **row** with #N/A **or** remove (the data for) Saint Helena, (Ascension and Tristan da Cunha) **isw**	**B1** **[1]**	**1.2**	do not allow "cell" or "entry" do not allow ignore instead of remove ignore superfluous comments

Question		Answer	Marks	AO	Guidance
10	(e)	**not** reliable because **oe** eg it's extrapolation eg 43.2 is outside the range of median ages eg *r* is not close to 1 eg scatter does not appear to be linear eg linear model is not a good fit for the data eg scatter not elliptical	**B1** **[1]**	**2.2b**	do not allow eg because it's not linear

Question		Answer	Marks	AO	Guidance
11	(a)	because Sam used a larger sample **oe**	**B1** **[1]**	**2.4**	allow eg because he/she/they used more data eg the sample is bigger
11	(b)	0.76 **or** $\frac{38}{50}$ **oe** BC	**B1** **[1]**	**1.1**	mark the final answer
11	(c)	0.19	**B1** **[1]**	**3.3**	**FT** $\frac{their\ 0.76}{4}$

Question		Answer	Marks	AO	Guidance
11	(d)	<table><tr><td>x</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td></tr><tr><td>f</td><td>21.52</td><td>20.19</td><td>7.11</td><td>1.11</td><td>0.07</td></tr></table> **BC**	**B1** **B1** **B1** **[3]**	**3.4** **3.4** **1.1**	for 1 correct frequency to 2 d.p. for 3 correct frequencies to 2 d.p. for all 5 correct to 2 d.p. **FT** use of B(4, their 0.19); allow **SC2** for all 5 frequencies awrt 22, 20, 7, 1, 0 or better allow **SC1** for 3 of the above frequencies awrt nearest whole number or better if **B0B0B0** allow **SC1** for probabilities: 0.430467…, 0.403895…, 0.142111…, 0.022223…, 0.001303 given to 3 dp or more; **FT** use of B(4, their 0.19) with $0 < p < 1$
11	(e)	by comparing theoretical and observed frequencies (or probabilities), the model is a (very) poor fit **oe**	**B1** **[1]**	**3.5a**	allow comparison of one pair of frequencies or one pair of probabilities;

Question		Answer	Marks	AO	Guidance
12		**DR**			
		$3(1+\tan^2\theta)+2\tan\theta-4[=0]$	**B1**	**3.1a**	correct substitution of $\sec^2\theta = 1+\tan^2\theta$ in equation; may be implied by $3+3\tan^2\theta+2\tan\theta-4[=0]$
		$3\tan^2\theta+2\tan\theta-1=0$	**M1**	**1.1**	3 term quadratic in $\tan\theta$ obtained following attempt at use of Pythagoras; may be implied if equation correct, otherwise substitution must be seen; allow one coefficient error
		$(3\tan\theta-1)(\tan\theta+1)[=0]$	**B1**	**2.1**	value(s) for $\tan\theta$ obtained from **their** quadratic by valid method; must see correct factorisation or correct use of formula **oe**
		$\tan\theta=-1\,,\tan\theta=\frac{1}{3}$	**A1**	**1.1**	both correct
		$-45°, 135°$, 18.4° to 18.435°, $-161.6°$ to $-161.565°$ or $-162°$	**A1**	**1.1**	any two values correct; dependent on award of previous **A1**
			A1	**3.2a**	all four values correct with no extras in the range; ignore values outside the range if **A0A0** allow **SC1** for $-\frac{\pi}{4},\frac{3\pi}{4}$, 0.32175 to 0.322, -2.8198 to -2.82 **NB B0M1B0A1A1A1** is possible
		Alternative method 1 $3+2\sin\theta\cos\theta-4\cos^2\theta=0$			from multiplying through by $\cos^2\theta$
		$3+\sin 2\theta-4(\frac{1}{2}(\cos 2\theta+1))\,[=0]$	**B1**		substitution of correct double angle formulae in correct equation
		$\sqrt{5}\sin(2\theta-63.4)=-1$ or $\sqrt{5}\cos(2\theta+63.4)=1$	**M1**		$R\sin(2\theta\pm\alpha)=k$ *or* $R\cos(2\theta\pm\alpha)=k$
		$\sin(2\theta-63.4)=-\frac{1}{\sqrt{5}}$ or $\cos(2\theta+26.6)=\frac{1}{\sqrt{5}}$	**M1** **A1**		value for $\sin(2\theta-63.4)=-\frac{1}{\sqrt{5}}$ or $\cos(2\theta+26.6)=\frac{1}{\sqrt{5}}$ obtained by valid method; **A1** if all correct

Question		Answer	Marks	AO	Guidance
		$-45°, 135°$, 18.4° to 18.435°,$-161.6°$ to $-161.565°$ or $-162°$	A1 A1		any two values correct; dependent on award of previous A1 all four values correct with no extras in the range; ignore values outside the range if **A0A0** allow **SC1** for $-\frac{\pi}{4}, \frac{3\pi}{4}$, 0.32175 to 0.322, -2.8198 to -2.82
		Alternative method 2 $(2\sin\theta\cos\theta)^2 = (4\cos^2\theta - 3)^2$ $4\sin^2\theta - 4\sin^4\theta = (1 - 4\sin^2\theta)^2$ **oe** **or** $4\cos^2\theta - 4\cos^4\theta = (4\cos^2\theta - 3)^2$ **oe** $20\sin^4\theta - 12\sin^2\theta + 1 = 0$ **or** $20\cos^4\theta - 28\cos^2\theta + 9 = 0$ $\sin^2\theta = 0.5, 0.1$ **or** $\cos^2\theta = 0.5, 0.9$ $-45°, 135°$, 18.4° to 18.435°,$-161.6°$ to $-161.565°$ or $-162°$	 B1 M1 B1 A1 A1 A1		from multiplying through by $\cos^2\theta$ and squaring both sides correct substitution of $\cos^2\theta = 1 - \sin^2\theta$ or $\sin^2\theta = 1 - \cos^2\theta$ in correct equation 3 term quadratic in $\sin^2\theta$ or $\cos^2\theta$ obtained following use of Pythagoras – may be implied if equation correct, otherwise substitution must be seen; allow one coefficient error values for $\sin^2\theta$ or $\cos^2\theta$ obtained from **their** quadratic by valid method; must see correct factorisation or correct use of formula both values of $\sin^2\theta$ or $\cos^2\theta$ correct any two values correct; dependent on award of previous **A1** all four values correct with no extras in the range; ignore values outside the range if **A0A0** allow **SC1** for $-\frac{\pi}{4}, \frac{3\pi}{4}$, 0.32175 to 0.322, -2.8198 to -2.82 **NB B0M1B0A1A1A1** is possible
			[6]		

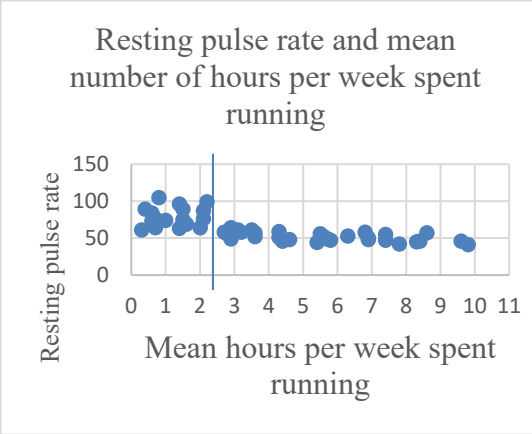
Question			Answer	Marks	AO	Guidance
13	(a)		H_0 $p = 0.494$ H_1 $p < 0.494$	B1	1.1	allow equivalent in words; do not allow percentages
			p is the **probability** that a person **(**aged 16 or over from England or Wales selected at random) is married or in a civil partnership	B1 [2]	2.5	or p is the **proportion** of people (aged 16 or over from England or Wales selected at random) who are married or in a civil partnership; must mention **either** married **or** in a civil partnership **B1B1** for other symbol instead of p used if correctly defined
13	(b)		use of $X \sim B(78,0.494)$ **soi**	M1	3.3	for calculation of a value for $P(X \leq k)$, ignore slip in notation **M0** for attempt at Normal approximation
			$(P(X \leq 27) =)0.0059 \ldots$ and$(P(X \leq 28) =)0.011 \ldots$ seen	M1	3.4	may see invBinom(0.01,78,0.494) = 28 for **M1M1;**
			$[0 \leq]X \leq 27$ or $[0 \leq]X < 28$ **oe**	A1 [3]	1.1	allow critical region < 28 **oe;** if **M0M0** allow **SC1** for correct critical region with no working or insufficient working
13	(c)		26 correctly compared with their 27 or their 28	M1	3.4	allow eg 26 is in critical region
			reject H_0 **or** accept H_1 **or** significant	A1	1.1	from correct critical region; condone from $0 < X \leq 27$ **oe**
			there is **sufficient evidence** at the 1% level to **suggest** that the **proportion** of people aged **16 or over** who are **married or in a civil partnership** is **lower** in 2024 than in 2022	A1 [3]	2.2b	dependent on award of previous two marks and correct critical region; allow percentage/probability but not "number" do not allow eg conclude / prove / indicate or other assertive statement instead of suggest; if **M0** allow **SC1** for $\mathbf{P(X \leq 26) = 0.003 < 0.01}$, so **reject H_0** and conclude there is **sufficient evidence** at the 1% level to **suggest** that the **proportion** of people aged **16 or over** who are **married or in a civil partnership** is **lower** in 2024 than in 2022

Question			Answer	Marks	AO	Guidance
13	(d)		0.01 **oe**	**B1** **[1]**	**1.2**	allow [P($X \le 27$) =] 0.005 946….

14	(a)		$\frac{16}{x^2} + \frac{3}{x} = 0$ $(-\frac{16}{3}, 0)$ and no others	**M1** **A1** **[2]**	**1.1** **1.1**	sets equal to 0 and obtains value(s) for x allow (–5.3, 0) or better; allow eg $x = -5.3$, $y = 0$ if **M0** allow **SC1** for **exact** coordinates unsupported
14	(b)	(i)	$\left[\frac{dy}{dx}\right] = -2 \times 16x^{-3} - 3x^{-2}$ **oe** $\left[\frac{dy}{dx}\right] = -32x^{-3} - 3x^{-2}$ **or** $-\frac{32}{x^3} - \frac{3}{x^2}$ **isw**	**M1*** **A1** **[2]**	**1.1** **1.1**	allow one sign error in coefficient; both terms correct and no extras
	(b)	(ii)	their $-32x^{-3} - 3x^{-2} = 0$ used to obtain value(s) for x $\left(-\frac{32}{3}, -\frac{9}{64}\right)$ **or** $\left(-10\frac{2}{3}, -\frac{9}{64}\right)$ **cao**	**M1dep*** **A1** **[2]**	**1.1** **1.1**	 allow eg -0.140625; allow eg $x = -\frac{32}{3}, y = -\frac{9}{64}$
14	(c)	(i)	$\left[\frac{d^2y}{dx^2}\right] = 96x^{-4} + 6x^{-3}$ **or** $\frac{96}{x^4} + \frac{6}{x^3}$	**M1** **A1** **[2]**	**1.1** **1.1**	differentiation of their $\frac{dy}{dx}$, dependent on award of **M1** in **14 (b)(i)**; allow one sign error in coefficient both terms correct

Question			Answer	Marks	AO	Guidance
14	(c)	(ii)	$96x^{-4} + 6x^{-3} < 0$	M1	2.1	putting their expression for $\frac{d^2y}{dx^2} < 0$ or $\frac{d^2y}{dx^2} = 0$ or $\frac{d^2y}{dx^2} \leq 0$ to find value(s) for x
			$x < -16$ or $-16 > x$ **cao**	A1 [2]	1.1	
14	(d)		$\int \frac{16}{x^2} + \frac{3}{x} dx = -\frac{16}{x} + 3\ln\|x\|$ **oe**	M1* A1	1.1 2.1	one term correct; allow omission of modulus sign both terms correct; ignore + c; allow omission of modulus sign
			$\left[\frac{-16}{-½} + 3\ln\|-½\|\right] - \left[\frac{-16}{-4} + 3\ln\|-4\|\right]$	M1dep*	1.1	allow omission of modulus sign; allow one incorrect sign but do not allow eg $F\left[-\frac{1}{2}\right] + F[-4]$
			$3\ln\|-½\| = 3\ln\frac{1}{2}$ and $3\ln\|-4\| = 3\ln 4$	M1dep*	2.1	**oe;** modulus seen and used to deal with both terms
			$28 - 9\ln 2$ **cao**	A1 [5]	1.1	may see eg $32 - 4 - 3\ln 2 - 6\ln 2$ **oe** as intermediate step
14	(d)		*Alternatively* $\int_{-4}^{-\frac{1}{2}} \frac{16}{x^2} + \frac{3}{x} dx = \int_{\frac{1}{2}}^{4} \frac{16}{x^2} - \frac{3}{x} dx$	M1*		by reflecting in y-axis and working with f($-x$) **oe;** may be awarded before first **M1;** condone incorrect reason eg reflection in x-axis; **M0** for use of $\int_{\frac{1}{2}}^{4} \frac{16}{x^2} + \frac{3}{x} dx$ by symmetry
			$\int \frac{16}{x^2} + \frac{3}{x} dx = -\frac{16}{x} - 3\ln x$ **oe**	M1* A1		one term correct; allow omission of modulus sign both terms correct; ignore + c; allow omission of modulus sign
			$\left[\frac{-16}{4} - 3\ln 4\right] - \left[\frac{-16}{\frac{1}{2}} - 3\ln\frac{1}{2}\right]$	M1dep*		dependent on correct integration and correct transformation
			$28 - 9\ln 2$ **cao**	A1		may see eg $32 - 4 - 3\ln 2 - 6\ln 2$ **oe** as intermediate step
				[5]		

Question			Answer	Marks	AO	Guidance
15	(a)	(i)	opportunity (sampling)	B1 [1]	2.5	allow convenience (sampling) do not allow eg convenient sampling; eg opportunistic sampling
15	(a)	(ii)	only people known to the personal trainer / his clients sampled **oe** **so** eg they are fitter than typical members of the population **oe** eg sample may not be representative **oe**	B1 [1]	2.3	allow **so** any eg which alludes to sample possibly giving unrepresentative values
15	(b)		negative (association)	B1 [1]	2.4	ignore adjectives such as weak, strong etc **allow** eg as mean hours spent running increases, resting pulse rate decreases; eg negative relationship; **do not allow** eg (negative) **correlation**; eg as pulse rate increases, mean hours per week spent running decreases

Question			Answer	Marks	AO	Guidance
15	(c)			B1 [1]	2.2b	approximately vertical line at about 2.5; **B0** if more than one line

Question			Answer	Marks	AO	Guidance
15	(d)		**LH region** 0.20936 is (fairly) small **oe isw**	**B1**	**3.4**	allow eg r_s is closer to 0 than to 1; eg low value of r_s; eg allow r_s close to 0
			0.41998 is not close to 0 **oe isw**	**M1**	**3.4**	allow eg p-value > 0.05 (or 0.01 or 0.1) eg p-value not small do **not** allow eg p-value (relatively) large eg high p-value
			insufficient evidence to suggest association (between mean time spent running and resting pulse rate) **oe**	**A1**	**2.2b**	may infer no association
			RH region –0.61349 is closer to –1 than 0 **oe isw**	**B1**	**3.4**	allow eg r_s close to −1 eg r_s is closer to –1 than 0; eg r_s is not small **B0** for eg r_s is large **oe**
			0.00031is close to 0 **oe**	**M1**	**3.4**	allow eg p-value < 0.05 (or 0.01 or 0.10) allow eg p-value is (very) small/low
			sufficient evidence to suggest (some) [negative] association (between mean time spent running and resting pulse rate) **oe**	**A1**	**2.2b**	may infer negative association
				[6]		

Question		Answer	Marks	AO	Guidance
16	(a)	**DR**			
		$\int \mathrm{d}P = \int (72t - 108)\mathrm{e}^{-0.8t}\,\mathrm{d}t$ **oe**	**B1**	**3.1a**	separation of variables; condone omission of integral signs or of dt ; allow P instead of $\int \mathrm{d}P$ on left hand side
		$\frac{-108}{-0.8}\mathrm{e}^{-0.8t}$ **oe seen**	**B1**	**2.1**	
		$72\left[t\frac{\mathrm{e}^{-0.8t}}{-0.8} - \int \frac{\mathrm{e}^{-0.8t}}{-0.8}\mathrm{d}t\right]$ **oe**	**M1***	**1.1**	integration by parts; allow sign errors only
			A1	**1.1**	all correct;
		$[P =] - 90t\mathrm{e}^{-0.8t} - 112.5\mathrm{e}^{-0.8t} + 135\mathrm{e}^{-0.8t}[+c]$ **oe**	**A1**	**1.1**	allow omission of + c; allow unsimplified
		$58.5 = -90 \times 0 \times \mathrm{e}^0 + 22.5\mathrm{e}^0 + c$ **oe**	**M1dep***	**3.3**	may be awarded after rearrangement; must see constant of integration; **NB** if expression incorrect, need to see full substitution for **M1**
		$P = 36 + 22.5\mathrm{e}^{-0.8t} - 90t\mathrm{e}^{-0.8t}$	**A1**	**1.1**	allow just $c = 36$ as long as "$P =$" seen following completion of integration; allow eg $P = 36 + 45(\frac{1}{2}e^{-0.8t} - 2te^{-0.8t})$; like terms must be collected and fractions must be in lowest terms
		Alternative method $\int \mathrm{d}P = \int (72t - 108)\mathrm{e}^{-0.8t}\,\mathrm{d}t$ **oe**	**B1**		separation of variables; condone omission of integral signs or of dt ; allow P instead of $\int \mathrm{d}P$ on left hand side
		$\frac{\mathrm{e}^{-0.8t}}{-0.8}$ **oe seen**	**B1**		may be embedded in integration by parts

Question		Answer	Marks	AO	Guidance
		$(72t-108)\frac{e^{-0.8t}}{-0.8}-\int 72\frac{e^{-0.8t}}{-0.8}dt$	**M1***		integration by parts; allow sign errors only
			A1		all correct
		$[P=]-90te^{-0.8t}-112.5e^{-0.8t}+135e^{-0.8t}+c$	**A1**		all correct; allow omission of $+c$; allow unsimplified
		$58.5=-90\times 0\times e^{0}+22.5e^{0}+c$ **oe**	**M1dep***		may be awarded after rearrangement; must see constant of integration
		$P=36+22.5e^{-0.8t}-90te^{-0.8t}$	**A1**		allow just $c=36$ as long as "$P=$" seen following completion of integration; allow eg $P=36+45(\frac{1}{2}e^{-0.8t}-2te^{-0.8t})$; like terms must be collected and fractions must be in lowest terms
			[7]		
16	**(b)**	**DR**			
		as $t\to\infty$, $(k)e^{-0.8t}\to 0$	**M1**	**3.4**	or $\lim_{t\to\infty}(k)\,e^{-0.8t}=0$; k is a constant; allow eg as t tends to infinity / as t becomes very large / in the long term, $(k)e^{-0.8t}$ tends to / converges to / approaches zero **oe** do not allow eg substitution of $t=\infty$
		so $P\to 36$. [Hence the model predicts that the population of puffins] does **not** recover to 58.5 thousand	**A1**	**1.1**	condone $P=36$
			[2]		

Question		Answer	Marks	AO	Guidance
17		**DR**			
		$[\bar{x} =]347.34$ seen	**B1**	**1.1**	**BC** allow 347.3 or 347; allow eg mean or $\bar{X}$, but no other symbol if seen
		$\left(s^2 = \frac{6036597-50\times347.34^2}{49}\right) = 88.637$ or $(s =)9.4147$ seen **BC**	**B1**	**1.1**	**NB** 88.6371428571; may see 9.4147(3010007) ; accept awrt 88.6 or awrt 9.41; do **not** allow 86.86 or 9.320; allow eg σ^2 or VAR[X]
		H_0: $\mu = 350$ H_1: $\mu < 350$	**B1**	**1.1**	allow use of other parameters (but not $\bar{x}$ or $\bar{X}$) if defined as [population] mean mass; allow if hypotheses stated in words: may earn **B1B0** if "population" omitted
		μ is the **population mean mass** of honey in a jar	**B1**	**2.5**	condone weight instead of mass
		$\mathrm{N}\left(350, \frac{\text{awrt } 88.6}{50}\right)$ **oe seen**	**B1**	**3.3**	**FT** their s^2 correct to 3 sf or better; may see N(350, 1.77(274285741) or $\mathrm{N}\left(350, \frac{9.415^2}{50}\right)$ or $\mathrm{N}(350, 1.331^2)$
		$(\mathrm{P}(\bar{X} < 347.34) =)$ awrt 0.023	**M1***	**3.4**	allow **M1** for correct probability found from $\mathrm{N}\left(350, \frac{\text{their awrt } 88.6}{50}\right)$; must see their distribution if value incorrect; condone slip in notation eg use of P(X < 347.34); allow for use of 347 or 347.3 instead of 347.34
		their 0.02287 correctly compared with 0.01	**M1dep***	**3.4**	allow eg 2.28% > 1%
		do not reject H_0 **or** accept H_0 **or** reject H_1 or not significant	**A1FT**	**1.1**	**A0** if their 0.0229 < 0.01
		there is **insufficient evidence** at the 1% level to **suggest** that the **mean mass** of honey in a jar is **less than** 350 grams	**A1**	**2.2b**	do not allow eg conclude / prove / indicate or other assertive statement instead of suggest; this mark is dependent on the award of all preceding marks apart from the fourth and fifth **B** marks ; condone weight instead of mass; must come from correct probability: $(\mathrm{P}(\bar{X} < 347.34) =)$ awrt 0.023

Question		Answer	Marks	AO	Guidance
		Alternatively, for the last 4 marks critical region is $\bar{X} < 346.9(0)$ or critical value is $\bar{X} = 346.9(0)$ to 3 or more sf	**M1***		allow **M1** for critical region found from $\mathrm{N}\left(350, \frac{\text{their awrt } 88.6}{50}\right)$; must see their distribution if value incorrect; condone slip in notation eg use of X
		347.34 correctly compared with their 346.90	**M1dep***		allow 347 or 347.3 compared with 346.9(0)
		do not reject H_0 **or** accept H_0 **or** reject H_1 or not significant	**A1FT**		**A0** if their 347.34 < their 346.9(0)
		there is **insufficient evidence** at the 1% level to **suggest** that the **mean mass** of honey in a jar is less than 350 grams	**A1**		do not allow eg conclude / prove / indicate or other assertive statement instead of suggest; this mark is dependent on the award of all preceding marks apart from the fourth and fifth **B** marks; must have correct critical region
		Alternatively, for the last 4 marks $z\left[=\frac{347.34-350}{\frac{9.414}{\sqrt{50}}}\right] = \text{awrt} - 1.998$	**M1***		allow **M1** for z found from $\mathrm{N}\left(350, \frac{\text{their awrt } 88.6}{50}\right)$; must see their distribution if value incorrect; allow for use of 347 or 347.3 instead of 347.34 NB may see $\text{awrt} - 2.03$ or $\text{awrt} - 2.25$ from 347.3 or 347
		their $-1.998 > -2.33$	**M1dep***		their z correctly compared with -2.326347877 ...to 2 or more dp
		do not reject H_0 **or** accept H_0 **or** reject H_1 or not significant	**A1FT**		**A0** if their $-1.998 < -2.33$
		there is **insufficient evidence** at the 1% level to **suggest** that the **mean mass** of honey in a jar is less than 350 grams	**A1**		do not allow eg conclude / prove / indicate or other assertive statement instead of suggest; this mark is dependent on the award of all preceding marks apart from the fourth and fifth **B** marks; z must be correct
			[9]		

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