GCE

Mathematics B MEI

H640/02: Pure Mathematics and Statistics

A Level

Mark Scheme for June 2024

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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 posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **number of required** 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 or the RM Assessor messaging system, or by email.

5. **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
E	Explanation mark 1
SC	Special case
^	Omission sign
MR	Misread
BP	Blank Page
Seen	
Highlighting	

Other abbreviations in mark scheme	Meaning
E1	Mark for explaining a result or establishing a given result
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.
BP	Blank Page
Seen	
Highlighting	

6. **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.

E
A given result is to be established or a result has to be explained. This usually requires more working or explanation than the establishment of an unknown result.

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. E marks are lost unless, by chance, the given results are established by equivalent working. 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			$(6-2)^2+(1--1)^2$ **soi**	**M1**	**1.1**	must be sum of two squares; may be implied by correct answer **or** by $(\pm 4)^2+(\pm 2)^2$
			$2\sqrt{5}$ **cao**	**A1**	**1.1**	mark the final answer; **B2** for correct answer unsupported
				[2]		

Question			Answer	Marks	AO	Guidance
2			$2e^x$ soi **or** -3 seen in exponent	**M1**	**1.1**	eg **M1** for $2e^x-3$ **or** $e^{\frac{1}{2}x-3}$;
			$y=2e^{x-3}$ **or** $f(x)=2e^{x-3}$ **oe isw**	**A1**	**1.1**	must be an equation; **B2** for correct answer with no working
				[2]		

Question			Answer	Marks	AO	Guidance
3	(a)		positively skewed	**B1**	**1.2**	
				[1]		
3	(b)		$10\times 0.5+5\times 3.2+5\times 1.8+10\times 1.4+20\times 0.2$ **oe**	**M1**	**1.1**	allow 1 incorrect class width **or** one incorrect frequency density may be implied by 5 + 16 + 9 + 14 + 4;
			48	**A1**		allow **SCB1** for correct answer unsupported
				[2]		

Question			Answer	Marks	AO	Guidance
4	(a)			**M1**	**1.1**	sine wave with 2 complete cycles between 0 and 2π which must be clear from labelling; condone eg waves of unequal amplitude or different length; allow labelling to override poor sketching; allow labelling in degrees for **M1** only
				A1	**1.1**	all correct with amplitude 1; ignore graph outside [0, 2π]
				[2]		
4	(b)		either $-\frac{\pi}{12}$ or $-\frac{5\pi}{12}$ **oe** seen **or** either $\frac{7\pi}{6}$ or $\frac{11\pi}{6}$ **oe** seen	**M1**	**3.1a**	**NB** from use of $\sin^{-1}\left(-\frac{1}{2}\right)$ **NB** – 0.262 or – 1.309; decimals correct to 2 dp or better **or** 3.665 or 5.760; decimals correct to 2 dp or better **M1** may be implied by two correct answers in radians
			$\frac{7\pi}{12}, \frac{11\pi}{12}, \frac{19\pi}{12}, \frac{23\pi}{12}$	**A1**	**1.1**	two correct values **NB** awrt 1.833, 2.880, 4.974, 6.021 or correct to 2 dp
				A1	**1.1**	all four values correct with no extras for $0 \leq \theta \leq 2\pi$ if **M0A0A0** allow **SCB1** for **two** correct answers in degrees **or SCB2** for all four correct in degrees 105, 165, 285 and 345
				[3]		

Question			Answer	Marks	AO	Guidance
5	(a)		<table><tr><td></td><td>M</td><td>M'</td><td></td></tr><tr><td>C</td><td>0.24</td><td>**0.12**</td><td>0.36</td></tr><tr><td>C'</td><td>**0.18**</td><td>0.46</td><td>**0.64**</td></tr><tr><td></td><td>0.42</td><td>**0.58**</td><td>1</td></tr></table>	**B1** **B1**	**1.1** **1.1**	entries in bold 0.46
				[2]		
5	(b)		$\frac{their\,0.46}{their\,0.58}$ **oe** $\frac{23}{29}$ or 0.79(31..)	**M1** **A1FT**	**1.1** **1.1**	must use values from their table; 0 < their 0.46 < their 0.58 < 1
				[2]		

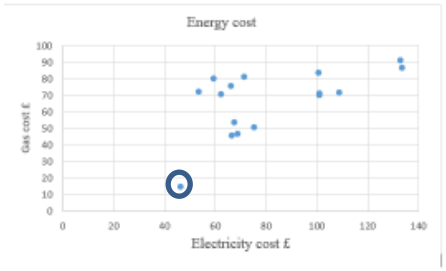
Question			Answer	Marks	AO	Guidance
6	(a)		[a =] 0.1	**B1**	**1.1**	
				[1]		
6	(b)		0.5	**B1FT**	**1.1**	FT their 0.1 + 0.4; 0 < their a < their 3a < 1
				[1]		
6	(c)		0.2 × 0.4 **oe** or their 3a × their a **oe** seen 2 × (0.2 × 0.4 + their 3a × their a) 0.22	**B1** **M1** **A1**	**1.1** **3.1a** **1.1**	0.2 × 0.4 **or** 0.3 × 0.1 **NB** 2 × (0.2 × 0.4 + 0.3 × 0.1); allow omission of 2; may be implied by 0.11
				[3]		

Question		Answer	Marks	AO	Guidance
7	(a)	$u_2 = 3, u_3 = 8, u_4 = 13$	B1 [1]	1.1	**B0** if wrongly attributed
7	(b)	divergent because difference between consecutive **terms** is not decreasing	E1 [1]	2.4	allow divergent because ratio of consecutive **terms** is tending to 1 not 0; divergent because the **terms** (in the sequence) are not tending to a finite limit **oe** divergent because **terms** tend to infinity **oe** do **not** allow divergent because not convergent **oe** divergent because **terms** (in the sequence) increase infinitely **oe** divergent because **terms** get bigger **oe**
7	(c)	$u_{30} = -2 + (30 - 1) \times 5$ used **oe**	M1	2.1	**eg** may see $3 + (29 - 1) \times 5$; a must be u_0, u_1, u_2, u_3 or u_4 in the AP and d must be 5; allow correct full list of terms from 3 to 138 for **M1** must see at least eg $-2 + 29 \times 5$
		143	A1 [2]	1.1	if **M0** allow **SCB1** for 143 not fully supported
7	(d)	$S_{30} = \frac{30}{2}(-2 + \textit{their}\ 143)$ **oe** **or** $S_{30} = \frac{30}{2}(2 \times (-2) + (30 - 1) \times 5)$ **oe**	M1	2.1	a must be -2 and d must be 5; allow sum of full list of terms from -2 to 143 for **M1;** allow if correct full list seen in part **(c)** only must see at least $15 \times (-2 +$ their 143) or $15 \times (-4 + 29 \times 5)$ for **M1**
		2115	A1 [2]	1.1	if **M0** allow **SCB1** for 2115 not fully supported

Question			Answer	Marks	AO	Guidance
8			$\frac{dy}{dx} = 6x^2 + 6mx - 9m$	**M1***	**3.1a**	differentiation of all 4 terms with 3 of the 4 terms differentiated correctly
				A1	**1.1**	all correct
			$(6m)^2 - 4 \times 6 \times (-9m)$ **oe** seen	**M1dep***	**3.1a**	discriminant for their $6, 6m$ and $-9m$; may see $(2m)^2 - 4 \times 2 \times (-3m)$
			two values of m obtained from their discriminant $36m^2 + 216m < 0$ or $36m^2 + 216m = 0$ **oe**	**M1**	**2.1**	dependent on obtaining discriminant from their derivative; **M0** for use of their discriminant > 0 or ≥ 0 **NB** $4m^2 + 24m < 0$ or $4m^2 + 24m = 0$
			0 and – 6 identified	**A1**	**1.1**	
			$-6 < m < 0$ **oe**	**A1**	**3.2a**	inequality or interval must be strict
				[6]		

Question			Answer	Marks	AO	Guidance
9	(a)		(probably) wouldn't include any pupils who eg cycle or eg walk to school (and hence biased towards certain methods of transport) **oe**	**B1**	**2.2b**	must refer to at least one of the given modes of transport
				[1]		
9	(b)		$\frac{107}{500} \times 60$	**M1**	**1.1**	allow slip in calculation of 500 if clearly their sum of all pupils; may be implied by 12.84 or 12.8
			13	**A1**	**1.1**	**B2** for 13 unsupported
				[2]		
9	(c)		**not** simple random sampling because every possible **sample** does not have an equal probability of being selected **oe**	**B1**	**2.4**	allow eg **no** because not possible to select every possible **sample** eg **not** simple random sampling because every pupil not equally likely to be selected do **not** allow eg **not** simple random sampling because it's systematic sampling
				[1]		

Question			Answer	Marks	AO	Guidance
10	(a)		$8^{\frac{1}{3}}$ or 2 seen	B1	1.1	
			$1+\left(\frac{1}{3}\right)\left(\frac{3x}{8}\right)+\left(\frac{1}{3}\right)\left(\frac{1}{3}-1\right)\frac{\left(\frac{3x}{8}\right)^2}{2!}+\cdots$	M1	1.1	two of the first three terms correct; ignore terms in x^3 and above; may be embedded; must see at least substitution for third term
			$\left(1+\frac{x}{8}-\frac{x^2}{64}+\cdots\right)$	A1	1.1	may be unsimplified; may be embedded
			$2+\frac{x}{4}-\frac{x^2}{32}$ or $2\left(1+\frac{x}{8}-\frac{x^2}{64}+\cdots\right)$ **isw**	A1	1.1	all three terms correct; ignore exra terms if **M0** allow **SCB1** for $\left(1+\frac{1}{2}x-\frac{1}{4}x^2\right)$ following the equivalent method with use of $\frac{3x}{2}$; may see eg $2+x-\frac{1}{2}x^2$ if **M0** allow **SCB2** for correct expansion not fully supported if **M1A0** allow **SCB1** for correct expansion not fully supported
				[4]		
10	(b)		$\lvert x\rvert<\frac{8}{3}$ **or** $-\frac{8}{3}<x<\frac{8}{3}$	B1FT	2.5	allow $\lvert x\rvert\leq\frac{8}{3}$ **or** $-\frac{8}{3}\leq x\leq\frac{8}{3}$; mark the final answer **FT** their $\left(1+\frac{a}{b}x\right)$
				[1]		

Question			Answer	Marks	AO	Guidance
11	(a)			B1	2.2b	
				[1]		
11	(b)		(weak) positive association **or** (weak) positive correlation	B1	1.1	allow eg as cost of electricity increases, cost of gas increases **oe**
				[1]		
11	(c)		0.09195 correctly compared with 0.05 or 0.025 only	M1	3.4	allow eg "*p*-value > 0.05"
			0.09195 > 0.025	A1	1.1	allow *p*-value > 0.025
			insufficient evidence [at the 5% level] to **suggest** any **association** between cost of gas and cost of electricity **isw**	A1	2.2b	**A0** if refers to correlation rather than association; dependent on award of previous **A1**
				[3]		

Question			Answer	Marks	AO	Guidance
12			$H_0: p = 0.1$ $H_1: p \neq 0.1$	**B1**	**1.1**	allow equivalent in words; do not allow percentages allow other variable only if correctly defined
			p is the probability that a (British) adult (selected at random) is a vegetarian	**B1**	**2.5**	or p is the proportion of adults that are vegetarian **B1B1** if other symbol instead of p used if correctly defined
			$P(X \geq k)$ found using B(112, 0.1), where k = 18, 19 or 20	**M1***	**3.3**	may be implied by $(P(X \geq 18)) = 0.0295 - 0.030$ or $(P(X \geq 19)) = 0.015 - 0.015331$ or $(P(X \geq 20)) = 0.0075 - 0.00754$ **NB M0** for $P(X = 19) = 0.00779$ **NB** $P(X \leq 17) = 0.97049\ldots$, $P(X \leq 18) = 0.984669$ ... and $P(X \leq 19) = 0.99246$ ... imply **M1**
			$[P(X \geq 19) =] 0.015 - 0.015331$	**A1**	**1.1**	or $[P(X \leq 18) =] 0.984669 - 0.985$ or 0.98
			their 0.015 correctly compared with 0.025 **or** their 0.985 correctly compared with 0.975	**M1dep***	**3.4**	
			do not accept H_0 **or** reject H_0 **or** accept H_1 **or** significant	**A1FT**	**1.1**	**A0** if their 0.015 > 0.025 or their 0.985 < 0.975
			sufficient evidence at the 5% level to **suggest** that the **probability** that an adult is vegetarian **is not** 0.10 **oe**	**A1**	**3.5a**	dependent on award of all other marks apart from second **B1** do not allow eg conclude / prove / indicate or other assertive statement instead of suggest
				[7]		

Question			Answer	Marks	AO	Guidance
12			*Alternatively, using critical region*			
			H_0 $p = 0.1$ H_1 $p \neq 0.1$	**B1**		allow equivalent in words; do not allow percentages allow other variable only if correctly defined
			p is the probability that a (British) adult (selected at random) is a vegetarian	**B1**		or p is the proportion of adults that are vegetarian **B1B1** if other symbol instead of p used if correctly defined
			critical region is $X \leq k \cup X \geq l$ $X \geq k$ found from calculation of probability; allow $k = 4$ or 5, $l = 18$, 19 or 20	**M1***		allow calculation of upper tail only for **M1**
			[critical region is X] ≥ 19 $\cup$ [X] $\leq$ 4	**A1**		from $P(X \geq 19) = 0.015 - 0.015331$ and $P(X \leq 4) = 0.010$ must see both tails for **A1**
			19 correctly compared with their critical value	**M1dep***	**3.4**	
			do not accept H_0 **or** reject H_0 **or** accept H_1 **or** significant	**A1FT**	**1.1**	**A0** if 19 < their critical value
			sufficient evidence at the 5% level to **suggest** that the **probability** that an adult is vegetarian **is not** 0.10 **oe**	**A1**	**3.5a**	dependent on award of all other marks apart from second **B1** do not allow eg conclude / prove / indicate or other assertive statement instead of suggest
				[7]		

Question			Answer	Marks	AO	Guidance
12			*Alternatively, using Normal approximation* H_0 $p = 0.1$ H_1 $p \neq 0.1$	**B1**		allow equivalent in words; do not allow percentages allow other variable only if correctly defined
			p is the probability that a (British) adult (selected at random) is a vegetarian	**B1**		or p is the proportion of adults that are vegetarian **B1B1** if other symbol instead of p used if correctly defined
			$P(X \geq 18.5)$ or $P(X \geq 19.5)$ found using N(11.2, 10.08)	**M1***		**NB M0** for $P(X = 19) = 0.006145$ (from normPdf(19, 11.2,$\sqrt{10.08}$) or $P(X = 19) = 0.00627$ (from using continuity correction, may see normCdf(18.5,19.5, 11.2,$\sqrt{10.08}$))
			or $P(X \geq 19.5) = 0.00447(1)$			**NB** $P(X \leq 19.5) = 0.99553...$ and $P(X \leq 18.5) = 0.989255…$ imply **M1**
			[$P(X \geq 18.5) =$ **]**$0.0107 - 0.011$	**A1**		
			their 0.0107 correctly compared with 0.025 or their 0.989 correctly compared with 0.975	**M1dep***		
			do not accept H_0 **or** reject H_0 **or** accept H_1 **or** significant	**A1FT**		**A0** if their $0.0107 > 0.025$ or their $0.989 < 0.975$
			sufficient evidence at the 5% level to **suggest** that the **probability** that an adult is vegetarian **is not** 0.10 **oe**	**A1**		dependent on award of all other marks apart from second **B1** do not allow eg conclude / prove / indicate or other assertive statement instead of suggest
				[7]		

Question			Answer	Marks	AO	Guidance
13			$2y\frac{dy}{dx}$	B1	1.1	chain rule
			$y + x\frac{dy}{dx}$	B1	3.1a	product rule
			(their previous terms) $+ 2x - 1 = 0$	B1	1.1	may award if "= 0" seen later, but not if RHS is $\frac{dy}{dx}$
			their $y + 2x - 1 = 0$	M1	2.1	substitution of $\frac{dy}{dx} = 0$; may follow (incorrect) rearrangement; dependent on award of at least one **B** mark **NB** $\frac{dy}{dx} = \frac{1-2x-y}{2y+x}$
			$(1-2x)^2 + x(1-2x) + x^2 - x = 1$ **or** $y^2 + \frac{(1-y)y}{2} + \frac{(1-y)^2}{4} - \frac{1-y}{2} = 1$	M1	3.1a	elimination of x or y using expression or value obtained from use of $\frac{dy}{dx} = 0$; dependent on award of at least one **B** mark
			$3x^2 - 4x[= 0]$ **or** $3y^2 + 2y - 5[= 0]$	A1	1.1	
			$x = 0, x = \frac{4}{3}$	M1	1.1	values of x **or** y found from their quadratic
			$y = 1, y = -\frac{5}{3}$	M1	1.1	values of y **or** x found from substitution of both x **or** both y values; must see substitution unless values correct **NB** may see extra points $y = -1$ or $\frac{1}{3}$ from substitution into original equation
			(0,1) and $\left(\frac{4}{3}, -\frac{5}{3}\right)$ **or** $x = 0, y = 1$ and $x = \frac{4}{3}, y = -\frac{5}{3}$	A1	3.2a	**A0** if extra points in final answer; dependent on fully correct working throughout; if **M0M0** allow **SCB1** for 1 correct pair of coordinates and no others
				[9]		

Question	Answer	Marks	AO	Guidance
	Alternatively $2x\frac{dx}{dy} - \frac{dx}{dy}$	**B1**		chain rule
	$x + y\frac{dx}{dy}$	**B1**		product rule
	(their previous terms) $+2y = 0$	**B1**		may award if "= 0" seen later, but not if RHS is $\frac{dy}{dx}$
	their $1 - 2x - y = 0$	**M1**		from setting denominator of $\frac{dx}{dy} = \frac{2y+x}{1-2x-y}$ equal to 0 or rearranging to find $\frac{dy}{dx} = \frac{1-2x-y}{2y+x}$ and setting equal to 0; dependent on award of at least one **B** mark
	$(1-2x)^2 + x(1-2x) + x^2 - x = 1$ or $y^2 + \frac{(1-y)y}{2} + \frac{(1-y)^2}{4} - \frac{1-y}{2} = 1$	**M1**		elimination of *x* or *y* using expression or value obtained from use of $\frac{dy}{dx} = 0$; dependent on award of at least one **B** mark
	$3x^2 - 4x[= 0]$ **or** $3y^2 + 2y - 5[= 0]$	**A1**		
	$x = 0, x = \frac{4}{3}$	**M1**		values of *x* **or** *y* found from their quadratic
	$y = 1, y = -\frac{5}{3}$	**M1**		values of *y* **or** *x* found from substitution of both *x* **or** both *y* values; must see substitution unless values correct **NB** may see extra points $y = -1$ or $\frac{1}{3}$ from substitution into original equation
	(0,1) and $\left(\frac{4}{3}, -\frac{5}{3}\right)$ **or** $x = 0, y = 1$ and $x = \frac{4}{3}, y = -\frac{5}{3}$	**A1**		**A0** if extra points in final answer; dependent on fully correct working throughout if **M0M0** allow **SCB1** for 1 correct pair of coordinates and no others
		9		

Question			Answer	Marks	AO	Guidance
14	(a)		not all the data were available	B1	2.4	LDS advantage must refer to data not being available **or** reference to #N/A
				[1]		
14	(b)		$57.7 - 1.5 \times (82.05 - 57.7)$ or $82.05 + 1.5 \times (82.05 - 57.7)$ seen	M1	1.1	
			outliers < 21.175 or outliers > 118.575	A1	2.2a	given correct to 1 dp or better; both regions needed; allow non-strict inequalities
			(hence all outliers in interval)	A1	2.2a	allow eg between 118.6 and 132.2
			(118.575,132.2]			allow strict or non-strict inequalities
			(since no outliers in lower tail)			if **M0** allow **SCB1** for both regions outliers < 21.175 or outliers > 118.575 unsupported; allow **SCB2** for all outliers in (118.575,132.2] unsupported
				[3]		
14	(c)		should **not** be removed since no reason to eg doubt that it's genuine data eg suspect it's been misrecorded eg doubt since from (US) government	B1	2.4	LDS advantage
				[1]		
14	(d)		**a typical** man is heavier than **a typical** woman, [since 79.9 > 69.5]	B1	2.2b	allow eg **an average** man is heavier than **an average** woman do **not** allow eg men are heavier than women **on average**
				[1]		

Question			Answer	Marks	AO	Guidance
14	(e)		**mean weight for men** is greater than **mean weight for women**, so **distribution for men** is located further along the number line than the **distribution for women** (by about 10 kg) **oe**	**B1**	**2.4**	allow **mean weight for men** greater than **mean weight for women**, so **men are heavier than women** (by about 10 kg) **oe** must refer to mean or average
			standard deviations (or variances) are approximately equal, so similar dispersion about the mean / variation in weights for men and women **oe**	**B1**	**2.2a**	must refer to standard deviation or variance
				[2]		

Question			Answer	Marks	AO	Guidance
15	(a) (i)		337	**B1**	**1.1**	
				[1]		
15	(a) (ii)		$\sqrt{\frac{1}{54}(6247066.6 - 55 \times 337^2)}$ ≈ 3.78	**B1**	**1.1**	**NB** $\sqrt{14.289} = 3.7800$ ... may see $\sqrt{\frac{6247066.6}{55} - 337^2} \times \sqrt{\frac{55}{54}}$ **or** $\sqrt{\frac{6247066.6}{54} - \frac{55 \times 337^2}{54}}$ **oe;** **AG** must see substitution of at least three of 6247066.6, 337, 55 and 54
				[1]		

Question			Answer	Marks	AO	Guidance
15	(b)		allow any two reasons eg distribution is (approximately) symmetrical eg distribution is (approximately) bell-shaped eg distribution is unimodal eg data is continuous	E1 E1	2.4 2.2b	
				[2]		
15	(c)		P($X < 330$) found from N(their 337, 3.78^2)	M1	3.3	may be implied by 0.032; allow a more precise value for 3.78 if found in part **(a)(ii)** **NB** eg N(– 9E999,330,337,3.78); **NB** may see $\sigma^2 = \frac{643}{45}$ or $z = \frac{330-337}{3.78} (= -1.85 \ldots)$
			100 × their 0.032	M1	3.4	
			awrt 3.2 **www**	A1	1.1	mark the final answer
				[3]		
15	(d)		($z =$) $\pm$ 2.3263 ... seen	B1	3.1a	to 2 or more dp
			their $z = \frac{330-\mu}{3.78}$	M1	2.1	
			338.79 $\approx$ 339	A1	3.2a	must be correct to 3 sf **A0** for $\mu \geq 339$ or $\mu > 339$
				[3]		

Question			Answer	Marks	AO	Guidance
15	(d)		*Alternatively using calculator* eg cdfNormal(-9.999×10^{999}, 330, 338, 3.78) = 0.017(155…) > 0.01 **or** eg cdfNormal(-9.999×10^{999}, 330, 338.5, 3.78) = 0.012(266…) > 0.01	**M1**		allow slip in calculation if intent is clear; allow for any value between 338 and 338.78 inclusive must see correct distributions if probabilities are wrong
			eg cdfNormal(-9.999×10^{999}, 330, 339, 3.78) = 0.0086(339…) < 0.01	**M1**		allow for any value between 338.8 and 339.5 **NB** critical value is 338.79
			hence minimum value for μ is 339	**A1**		must be correct to 3 sf; **A0** for $\mu \geq 339$ or $\mu > 339$
				3		

15	**(e)**		H_0: $\mu = 340$ H_1: $\mu < 340$	**B1**	**1.1**	do not allow $\bar{X}$ or X, but allow other symbol if defined as [population] mean volume; allow equivalent in words
			μ is the **population mean** (volume of drink in a bottle of Fizzipop)	**B1**	**2.5**	
			N $\left(340, \frac{3.78^2}{100}\right)$ **oe** seen	**M1***	**3.3**	may be implied by $0.0477 - 0.048$ may see N(340,0.378^2) may see $\sigma^2 = \frac{643}{4500}$
			[P($\bar{X} < 339.37$) =]$0.0477 - 0.048$	**A1**	**3.4**	allow slip such as X for $\bar{X}$ but do not allow μ
			their 0.048 correctly compared with 0.05	**M1dep***	**3.4**	
			do not accept H_0 **or** reject H_0 **or** accept H_1 **or** significant	**A1FT**	**1.1**	
			there is **sufficient evidence** at the 5% level to **suggest** that the **mean volume** of drink in a bottle of Fizzipop is **less than** 340 ml **oe**	**A1**	**3.5a**	dependent on award of all other marks apart from second **B1** do not allow eg conclude / prove / indicate or other assertive statement instead of suggest
				[7]		

15	**(e)**		*Alternatively* H_0: $\mu = 340$ H_1: $\mu < 340$	**B1**	**1.1**	do not allow $\bar{X}$ or X, but allow other symbol if defined as [population] mean volume allow equivalent in words
			μ is the **population mean** (volume of drink in a bottle of Fizzipop)	**B1**	**2.5**	
			$N\left(340, \frac{3.78^2}{100}\right)$ **oe** seen	**M1***	**3.3**	may be implied by $339.378 - 339.38$ may see N(340,0.378²) may see $\sigma^2 = \frac{643}{4500}$
			[critical region is $\bar{X} <$]$339.378 - 339.38$	**A1**	**3.4**	or [critical value is $\bar{X} =$]$339.378 - 339.38$; allow slip such as X for $\bar{X}$ but do not allow μ
			339.37 correctly compared with their 339.378	**M1dep***	**3.4**	allow eg so 339.37 is in the critical region if critical region explicitly identified
			do not accept H_0 **or** reject H_0 **or** accept H_1 **or** significant	**A1FT**	**1.1**	**A0** if 339.37 > their 339.378
			there is **sufficient evidence** at the 5% level to **suggest** that the **mean volume** of drink in a bottle of Fizzipop is **less than** 340 ml **oe**	**A1**	**3.5a**	dependent on award of all other marks apart from second **B1** do not allow eg conclude / prove / indicate or other assertive statement instead of suggest
				[7]		

15	**(e)**		*Alternatively, using standard Normal distribution* H_0: $\mu = 340$ H_1: $\mu < 340$	**B1**		do not allow $\bar{X}$ or X, but allow other symbol if defined as [population] mean volume allow equivalent in words
			μ is the **population mean** (volume of drink in a bottle of Fizzipop)	**B1**		
			$N\left(340, \frac{3.78^2}{100}\right)$ **oe** seen	**M1***		may be implied by $z = -1.667$ may see N(340,0.378²) may see $\sigma^2 = \frac{643}{4500}$
			$[z =] -1.667$	**A1**		
			their z correctly compared with – 1.64485 to 2 or more dp **oe**; must come from N(340, σ)	**M1dep***		
			do not accept H_0 **or** reject H_0 **or** accept H_1 **or** significant	**A1FT**		**A0** if their $z > -1.64485$
			there is **sufficient evidence** at the 5% level to **suggest** that the **mean volume** of drink in a bottle of Fizzipop is **less than** 340 ml **oe**	**A1**		dependent on award of all other marks apart from second **B1** do not allow eg conclude / prove / indicate or other assertive statement instead of suggest
				[7]		

Question			Answer	Marks	AO	Guidance
16			$\int \frac{dy}{y} = \int \frac{9dx}{(x-1)(x+2)}$ **oe**	**M1**	**3.1a**	separation of variables; condone omission of integral signs **or** of dx and/or dy; allow 1 slip such as omission of 9 or sign error in bracket
			$\frac{A}{x-1} + \frac{B}{x+2}$	**M1**	**3.1a**	allow 1 sign error in bracket
			$\frac{9}{(x-1)(x+2)} = \frac{3}{(x-1)} - \frac{3}{(x+2)}$ **oe**	**A1**	**1.1**	one of two terms correct
				A1	**1.1**	all correct
			$\ln y = A\ln(x-1) + B\ln(x+2) + c$	**M1***	**2.1**	any ln integral correct; **FT** their A and B; condone omission of + c
			$\ln y = 3\ln(x-1) - 3\ln(x+2) + c$ **oe**	**A1**	**1.1**	all three terms correct including + c; may see $\frac{1}{9}\ln y = \frac{1}{3}\ln(x-1) - \frac{1}{3}\ln(x+2) + c$ **NB** $\ln y + c$ is equivalent to $\ln Ay$ where A is a constant
			$\ln 16 = 3\ln(2-1) - 3\ln(2+2) + c$	**M1dep***	**2.1**	substitution of (2, 16) in their expression; may be implied by eg $\ln 16 = 3\ln 1 - 3\ln 4 + c$; must see substitution for incorrect expressions
			$c = 5\ln 4$ **or** $\ln 4^5$ **or** $\ln 1024$	**A1**	**1.1**	may see $c = \frac{5}{9}\ln 4$ **oe** allow exact equivalents only
			$\ln \frac{\text{their}1024(x-1)^A}{(x+2)^B}$ **oe**	**M1**	**3.1a**	correctly combines their RHS into a single logarithm; their $+ c$ must be correctly incorporated into their $\ln f(y)$ or their $\ln f(x)$
			$\ln y = \ln \frac{1024(x-1)^3}{(x+2)^3}$	**A1**	**1.1**	all correct

Question	Answer	Marks	AO	Guidance
	$e^{\ln y} = e^{\ln\frac{A(x-1)^3}{(x+2)^3}}$ **oe**	**M1**	**2.1**	correctly exponentiates their expressions, may be awarded before combination into single logarithm
	$y = \frac{1024(x-1)^3}{(x+2)^3}$	**A1**	**3.2a**	all correct; must see "$y =$" at some stage
		12		
	Alternatively, for the last 6 marks			
	$\ln\left\{\frac{(x-1)^A}{(x+2)^B} \times e^c\right\}$ **oe**	**M1dep***		correctly combines their RHS into a single logarithm;
	$\ln y = \ln\left[\frac{(x-1)^3}{(x+2)^3} \times e^c\right]$ **oe**	**A1**		all correct
	$e^{\ln y} = e^{\ln\frac{(x-1)^A}{(x+2)^B} \times D}$ **oe**	**M1**		correctly exponentiates their expressions; may be awarded before combining into single logarithm
	$y = \frac{(x-1)^3}{(x+2)^3} \times D$	**A1**		all correct
	$16 = \frac{(2-1)^A}{(2+2)^B} \times D$ **oe**	**M1**		substitution of (2, 16) in their expression; may be implied by eg $16 = \frac{1^3}{4^3} \times D$; must see substitution for incorrect expressions; may be awarded before exponentiating
	$y = \frac{1024(x-1)^3}{(x+2)^3}$	**A1**		all correct; must see "$y =$" at some stage

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