GCE

Mathematics A

H240/02: Pure Mathematics and Statistics

A Level

Mark Scheme for June 2022

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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.

Text Instructions

1. Annotations and abbreviations

Annotation in RM assessor	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.

2. Subject-specific Marking Instructions for A Level Mathematics A

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 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 **3 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 B (MEI) the rubric is not specific about the level of accuracy required, so this statement reads "2 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.

Sig figs: "0.348 (3 sf)" means "answer that rounds to 0.348", ISW. eg 0.347652 = 0.35 scores A1, 0.348 = 0.35 scores A1, but 0.35 alone scores A0
Other forms for probabilities Allow eg 20% or 1 in 5, but not odds eg 1:4

Question			Answer	Mark	AO	Guidance
1	(a)	DR	$\frac{x(x+2)-(x-1)(x+1)}{(x+1)(x+2)}$ or $\frac{x^2+2x-x^2+1}{x^2+3x+2}$ oe (= 0)	M1 M1	1.1 1.1	M1 for $x(x+2)-(x+1)(x-1)$ oe Multiply out brackets. Allow one error Ignore denominator even if "= 0"
			$x = -\frac{1}{2}$	A1	1.1	NB correct with no working: SC B1
			Alternative method $x(x+2) = (x+1)(x-1)$ $x^2 + 2x = x^2 - 1$ or $2x = -1$ oe $x = -\frac{1}{2}$	M1 M1 A1		M1 for attempt "cross-multiply". Multiply out brackets. Allow one error
				[3]		
1	(b)		**DR** Solve quadratic in $\frac{1}{x^3}$ or x^3 or u $(= x^3$ or $\frac{1}{x^3})$ using any correct method.	M1	3.1a	or cubic in x Condone quadratic in x with $x = \frac{1}{x^3}$ or $x = x^3$ Must see attempt at correct method for this mark Allow arithmetical errors
			$\frac{1}{x^3}$ (or u) = 1 & $-\frac{1}{8}$ or x^3 (or u) = 1 & –8 or correct factorisation of quadratic	B1	1.1	Can be scored without M1 Condone $x = 1, -\frac{1}{8}$ or $x = 1, -8$ Ignore $x^3 = 0$, if seen, for this mark
			$x = 1$& $x = -2$ with no extras	B1f	1.1	ft their x^3 or $\frac{1}{x^3}$ If also $x = 0$, B0 NB correct with no working: M0B0B1
				[3]		
1	(c)		**DR** eg $(x^2 - 7)\ln 3 = \ln\frac{1}{243}$ or $x^2 - 7 = \log_3\left(\frac{1}{243}\right)$ or $3^{x^2-7} = 3^{-5}$ or $x^2 - 7 = -5$ or $3^{x^2} = 3^2$	M1	3.1a	Condone incorrect or omitted brackets Any correct step after log(both sides) or ANY correct step using indices
			$x = \pm\sqrt{2}$ or ±1.41 (3 sf)	A1	1.1	NB correct with no working or T & I: SC B1

Question			Answer	Mark	AO	Guidance
				[2]		
2	**(a)**		$(4\mathbf{i} + 2\mathbf{j} - 5\mathbf{k}) - (3\mathbf{i} + 2\mathbf{j})$ $(= \mathbf{i} - 5\mathbf{k})$ or $(3\mathbf{i} + 2\mathbf{j}) - (4\mathbf{i} + 2\mathbf{j} - 5\mathbf{k})$ $(= 5\mathbf{k} - \mathbf{i})$	**M1**	**1.1**	**b** − **a** or **a** − **b** attempted, using **i**, **j**, **k** or column vectors May be implied by calculation seen
			$AB = \sqrt{26}$ or 5.10 (3 sf) or 5.1	**A1** **[2]**	**1.1**	www. Correct answer, no working: M1A1 Mark(s) cannot be gained retrospectively in (b)
2	**(b)**		$'26' = (p-3)^2 + 4 + 9 + (p-4)^2 + 4 + 4$	**M1**	**3.1a**	Attempt $AB^2 = BP^2 + PA^2$ (involving p) ft their AB
			Alternative methods for M1			
			Attempt $\lvert PC\rvert^2 = (\text{their radius})^2$	**M1**		or $(\frac{7}{2} - p)^2 + 4 + \frac{1}{4} = \frac{13}{2}$
			Attempt $\overline{PA} \cdot \overline{PB} = 0$	**M1**		or $((3-p)\mathbf{i} + 2\mathbf{j} + 3\mathbf{k}) \cdot ((4-p)\mathbf{i} + 2\mathbf{j} - 2\mathbf{k}) = 0$
			$p^2 - 7p + 10 = 0$ oe or $(p - \frac{7}{2})^2 = \frac{9}{4}$	**A1f**	**1.1**	Correct simplified equation, ft their (a), ie: or $p^2 - 7p + \frac{46 - \text{their } a^2}{2} = 0$ or $(p - \frac{7}{2})^2 = \frac{\text{their } a^2 - 17}{4}$
			$p = 2$ or 5	**A1f** **[3]**	**1.1**	ft only their (a)
3	**(a)**		(No because) they differ only by a constant or eg $c_2 = c_1 + \frac{1}{3}$, or $\frac{1}{3}$ is part of Ben's c If definite integral found, answers are same If differentiate, answers same	**B1** **[1]**	**1.2**	oe, eg They may have different constants of integration Only the "c"s are different Not "Both are correct" or "just different correct methods"
3	**(b)**	**(i)**	$\left[\frac{(1+x)^{-1}}{-1}\right]_1^a$ or $\left[-\frac{1}{u}\right]_2^{a+1}$ or $\left[-\frac{1}{\sqrt{u}}\right]_4^{(a+1)^2}$ oe	**M1**	**1.1**	Attempt integral, must be of form $k(1+x)^{-1}$ or ku^{-1} or $ku^{-0.5}$ (if from substitution $u = (1+x)^2$) Ignore limits
			$= \frac{(1+a)^{-1}}{-1} + \frac{1}{2}$ oe	**M1**	**1.1**	Attempt substitute appropriate limits into their integral
			$(= \frac{1}{2} - \frac{1}{1+a})$ $= \frac{a-1}{2(a+1)}$	**A1** **[3]**	**1.1**	cao oe single fraction

Question			Answer	Mark	AO	Guidance
3	(b)	(ii)	$\frac{a-1}{2(a+1)} = \frac{1}{3}$ or their (b)(i) (limits subst'd) $= \frac{1}{3}$	M1	1.1	or their new attempt at $\int_1^a \frac{1}{(1+x)^2}\,dx = \frac{1}{3}$
			$a = 5$	A1 [2]	1.1	cao
3	(c)		**DR**			Allow incorrect use of brackets throughout Allow ln(…) instead of ln|…|
			$\frac{1}{2}\left[\ln\left\|\sin 2x + 2\right\|\right]_0^{\frac{1}{12}\pi}$	M1	1.1	Allow $k\ln(\sin 2x + 2)$, k any constant. Ignore limits
			$= \frac{1}{2}[\ln(\sin\frac{1}{6}\pi + 2) - \ln(0 + 2)]$	M1	1.1	Attempt substitute <u>both</u> correct limits into their log integral. Allow numerical errors
			$= \frac{1}{2}\left(\ln(\frac{5}{2}) - \ln 2\right)$	A1	1.1	Allow × any k, otherwise any correct form without trig.
			$= \frac{1}{2}\ln\frac{5}{4}$ oe, eg $\ln\frac{\sqrt{5}}{2}$	A1 [4]	2.1	Correct one-term exact result. ISW, eg ignore decimal NB No working, no marks.
			Alternative methods $u = \sin 2x + 2$, or $u = \sin 2x$ $\frac{1}{2}\int_2^{5/2}\frac{1}{u}\,du$ or $\frac{1}{2}\int_0^{1/2}\frac{1}{u+2}\,du$ $\frac{1}{2}\left[\ln u\right]_2^{5/2}$ or $\frac{1}{2}\left[\ln(u+2)\right]_0^{1/2}$	M1		Attempt substitute and integrate and obtain $k\ln u$ or $k\ln(u + 2)$, k any constant; ignore limits
			$(= \frac{1}{2}\left[\ln(\sin 2x + 2)\right]_0^{\frac{1}{12}\pi})$			(May not see this step)
				M1		Attempt substitute their limits into their log integral. but not limits for wrong variable, eg not $\ln\frac{\pi}{12} - \ln 0$ Allow numerical errors
			$\frac{1}{2}(\ln(\frac{5}{2}) - \ln 2)$	A1		Correct exact result, any form without trig. Allow × any k

Question			Answer	Mark	AO	Guidance
			$= \frac{1}{2}\ln\frac{5}{4}$ oe, eg $\ln\frac{\sqrt{5}}{2}$	**A1**		cao, ISW, eg ignore decimal answer
4			$20 + 20\times r + 20\times r^2 + ...$ or $20 \times \frac{1-r^n}{1-r}$	**M1**	**3.1b**	Sum of a GP implied. Allow any r, eg $r = 0.05$
			$20 \times \frac{1-0.95^n}{1-0.95} = 205$	**A1**	**1.1**	Correct equation
			$0.95^n = \frac{195}{400}$ or $\frac{39}{80}$ or 0.4875	**A1**	**1.1**	Allow 0.487 or 0.488
			$n = \frac{\ln 0.4875}{\ln 0.95}$ oe or $n = \log_{0.95}(\frac{39}{80})$ oe	**M1**	**2.1**	or $0.95^{14} = 0.4875$ or 0.487 or 0.488 seen. Can be implied by their answer ft their equation of form $a^n = b$ (dep M1 gained and $b > 0$)
			(Number of steps =) 14	**A1** **[5]**	**1.1**	cao. Allow $n = 14$. Allow 14.0. Allow ≈ 14
			Alternative method Sum of GP implied	**M1**		
			$20 + 20\times r + 20\times r^2 + ...$	**M1**		Attempt add $\underline{\geq}$ 10 terms. Allow any value of r for this mark
			$20 + 20\times 0.95 + 20\times 0.95^2 + ... + 20\times 0.95^{13}$	**A1**		Correct 14 terms added
			$= 205$ (3 sf)	**A1**		
			Number of steps = 14	**A1** **[5]**		NB Unsupported correct answer: SC B3
			Alternative (incorrect) methods using r = 1.05, or $\frac{1}{0.95}$ or $\frac{20}{19}$			(For info' only: $r = \frac{1}{0.95}$ or $\frac{20}{19}$ comes from misinterpreting "lowest" to mean "shortest")
			$20 + 20\times r + 20\times r^2 + ...$ or $20 \times \frac{1-r^n}{1-r}$	**M1**		Allow any value of r for this mark
			$20 \times \frac{1-\left(\frac{1}{0.95}\right)^n}{1-\frac{1}{0.95}} = 205$ or $20 \times \frac{1-\left(\frac{20}{19}\right)^n}{1-\frac{20}{19}} = 205$	**A1**		oe using 1.05. Correct equation
			$\left(\frac{20}{19}\right)^n = \frac{117}{76}$ or $1.05^n = 1.51$ or 1.54	**A1**		

Question			Answer	Mark	AO	Guidance
			$n = \dfrac{\ln\frac{117}{76}}{\ln\frac{20}{19}}$ or $\ln_{1.053} 1.539$ or $\ln_{1.05} 1.51$ Number of steps = 8 or 9	**M1** **A0**		oe, eg $\dfrac{\ln 1.539}{\ln 1.053}$ or $\dfrac{\ln 1.51}{\ln 1.05}$ ft their "$\frac{117}{76}$" Can be implied by their answer
5	**(a)**		**DR** $\frac{dy}{dx} = 3x^2 - 6x + 4 = 0$ $b^2 - 4ac = -12$ or D$=-12$ or $3(x-1)^2 + 1 = 0$ oe No (real) roots or no value of x, or can't $\sqrt{\text{negative}}$ or gradient always +ve.	**M1** **A1** **[2]**	**3.1a** **1.1**	Differentiate & equate to 0. May be implied by calc of D or $x = \dfrac{6 \pm \sqrt{36-48}}{6}$ or $x = \dfrac{6 \pm i\sqrt{12}}{6}$ oe Must see justification as line above, no errors, & statement Other correct forms of the quadratic equation and justification may be seen.
	(b)		**DR** $\frac{d^2y}{dx^2} = 6x - 6 = 0$ $x = 1$ gives a point of inflection or $x = 1$ & show that, either side of this point, gradient does not change sign or second derivative does change sign	**M1** **A1** **[2]**	**1.1** **2.2a**	Differentiate their $\frac{dy}{dx}$ and = 0. Can be implied by $x = 1$ Statement "$x = 1$ gives a point of inflection" is enough. or This equation has one root. (so curve has one inflection) Not just "$x = 1$" Ignore y-coordinate
6	**(a)**		<table><tr><th></th><th>One-one</th><th>Many-one</th><th>Own inverse</th><th>Not a function</th></tr><tr><td>**1**</td><td></td><td>√</td><td></td><td></td></tr><tr><td>**2**</td><td></td><td></td><td></td><td>√</td></tr><tr><td>**3**</td><td>√</td><td></td><td>√</td><td></td></tr><tr><td>**4**</td><td>√</td><td></td><td></td><td></td></tr><tr><td>**5**</td><td></td><td>√</td><td></td><td></td></tr></table>	**B4** **[4]**	**1.2** **1.2** **1.1** **2.2a**	B4 for all 5 rows correct B3 for 3 or 4 rows correct B2 for 2 rows correct B1 for 1 row correct
6	**(b)**		$\geq \frac{1}{2}$	**B1**	**1.2**	$\geq \frac{1}{2}$ soi, no top limit (except ∞). Allow $> \frac{1}{2}$ Allow f(x) or $\frac{1}{x}$ or any letter or none for 1st B1

Question			Answer	Mark	AO	Guidance
			$\{y: y \geq \frac{1}{2}\}$, $\{y: \frac{1}{2} \leq y < \infty\}$, $\{y: \frac{1}{2} \leq y \leq \infty\}$ or $[\frac{1}{2}, \infty)$ or $[\frac{1}{2}, \infty]$	**B1** **[2]**	**2.5**	Correct range in set notation. Any letter (not x) or $\frac{1}{x}$ or f(x)
7	**(a)**					NB Other correct methods may be seen
			$(3m + 0)^2 = 9m^2$	**B1**	**3.1a**	$9m^2$ alone, not as part of longer expression
			$(3m + 1)^2$ | $(3m + 2)^2$ $= 9m^2 + 6m + 1$ | $= 9m^2 + 12m + 4$	**M1**	**1.1**	At least one of these expansions attempted using $r = 1$ or 2. Must include three (or four) terms, Allow one error
			$= 3(3m^2 + 2m) + 1$ | $= 3(3m^2 + 4m + 1) + 1$ or $3(3m^2 + 4m) + 4$	**A1**	**2.1**	At least one of these seen explicitly
			None of these is of the form $3n + 2$ Allow "$\neq 3n + 2$"	**A1** **[4]**	**3.2a**	Must see the statement oe. Can be seen once at end or with each separate case Dep complete method, with all three cases seen
			Alternative method 1 $(3m + r)^2$ $(= 9m^2 + 6mr + r^2)$ $= 3(3m^2 + 2mr) + r^2$ $= 3n + r^2$ But $r^2 = 0$, 1 or 4 Hence not in the form $3n + 2$ for any r	 **M1** **A1** **B1** **A1**		 Attempted. Must include 3 (or 4) terms, Allow one error Explicit Must see the statement oe Dep complete method
			Alternative method 2 Let $(3m + r)^2 = 3n + 2$ $3(3m^2 + 2mr - n) = 2 - r^2$ Hence $2 - r^2$ is divisible by 3 But $2 - 0^2 = 2$, $2 - 1^2 = 1$, $2 - 2^2 = -2$ None of these is divisible by 3	 **M1** **A1** **B1** **A1**		

Question			Answer	Mark	AO	Guidance
7	(a)	ctd	**Alternative method 3** $(3m)^2 = (9m^2 - 2) + 2$ $(3m + 1)^2 = (9m^2 + 6m - 1) + 2$ $(3m + 2)^2 = (9m^2 + 12m + 2) + 2$ $(9m^2 - 2) = 3(3m^2) - 2$ $(9m^2 + 6m - 1) = 3(3m^2 + 2m) - 1$ $(9m^2 + 12m + 2) = 3(3m^2 + 4m) + 2$ Hence none is divisible by 3	**B1** **M1** **A1** **A1**		 Allow one arithmetical error Both correct or $3(3m^2 - \frac{2}{3}) + 2$ or $3(3m^2 + 2m - \frac{1}{3}) + 2$ or $3(3m^2 + 4m + \frac{2}{3}) + 2$ None of the brackets is an integer
7	(b)		Either imply three digits all of the same type or imply three digits all of different types P(0, 0, 0) or P(1, 1, 1) or P(2, 2, 2): $\left(\frac{1}{3}\right)^3$ P(0, 1, 2): $\left(\frac{1}{3}\right)^3 \times 6$ or $1 \times \frac{2}{3} \times \frac{1}{3}$ oe	**M1*** **M1 dep** **M1 dep**	**3.1a** **1.1** **2.1**	Could be numerical or algebraic or in words If listed, must be clear which ones are selected M1 for $\left(\frac{1}{3}\right)^3$ associated with at least one of these M1 for $\left(\frac{1}{3}\right)^3 \times k$ where k = 4, 5 or 6, associated with (0, 1, 2)
			Alternative method for 2nd & 3rd M1M1 No. of cases = $3^3 = 27$ No. divisible by 3 = (3 + 6 =) 9	 **M1** **M1**		 Allow 7 or 8
			$\frac{9}{27}$ or $\frac{1}{3}$ or 0.333 (3 sf)	**A1**	**1.1**	Correct answer with no working: M0M0M0A0

Question			Answer	Mark	AO	Guidance
				[4]		
8			**Summary method:** Express V in terms of h Differentiate V with respect to h Attempt chain rule, Attempt separate variables Correct integrals Substitute correct limits Answer	 **B1** **M1** **M1** **M1** **A1** **M1** **A1**	 **3.3** **3.4**	 Correct substitution NOT if $h = 50$ or $r = 50\tan 30$ used Resulting equation must involve exactly 2 variables Their equation must involve exactly 2 variables Ignore limits Integrals must be of correct forms (see examples below) <u>Note 1</u> Candidates who substitute numerical values for h or V or r may be able to score the 2nd and/or 3rd M1 marks, but probably nothing else. See the example of this below. <u>Note 2</u>. There is a special case for candidates who use $r = h\sin 30$ (answer $\frac{625\pi}{4}$ or 491). These can score all 4 M-marks and the final A1 <u>Note 3.</u> The chain rule may be used to find $\frac{dV}{dt}$ or $\frac{dh}{dt}$ or $\frac{dV}{dh}$ or $\frac{dV}{dr}$ or other derivatives. Two of the example methods below illustrate use of $\frac{dV}{dt}$ and $\frac{dV}{dr}$, but use of other derivatives can also lead to correct methods.

Question			Answer	Mark	AO	Guidance
8	ctd		**Example method 1**			
			$V = \frac{\pi}{3}(h\tan 30^{o})^2 h$ or $V = \frac{\pi}{3}\left(\frac{h}{\sqrt{3}}\right)^2 h$ oe	**B1**	**3.3**	or $V = \frac{\pi}{9}h^3$ oe
			$\frac{dV}{dh} = \frac{\pi}{3}h^2$	**M1**	**3.4**	Attempt differentiate their V in terms of h only NOT if $h = 50$ or $r = 50\tan 30$ used.
			$\frac{dV}{dt} = \frac{\pi}{3}h^2\frac{dh}{dt}$ oe or $\frac{dh}{dt} = \frac{3}{\pi h^2}\frac{dV}{dt}$	**M1**	**2.1**	Attempt use chain rule for $\frac{dV}{dt}$ or $\frac{dh}{dt}$ in terms of t & h only
			$("\frac{\pi}{3}h^2\frac{dh}{dt}" = -2h$ oe or $\frac{dh}{dt} = \frac{-6}{\pi h})$			(Set their $\frac{dV}{dt} = -2h$)
			$\pi\int_{50}^{0} h\,dh = -\int_{0}^{t} 6\,dt$ oe	**M1**	**1.1**	Attempt separate variables in their equation in terms of h and t only (not V or r). Integral signs not essential
			$\left[\frac{\pi h^2}{2}\right]_{50}^{0} = \left[-6t\right]_{0}^{t}$ oe	**A1**	**2.1**	Correct integrals, any limits or none
			$-\pi\times\frac{50^2}{2} = -6t$	**M1**	**1.1**	Substitute correct limits into integrals of forms ah^2 & bt OR substitute $t = 0$ & $h = 50$ to find c <u>and</u> substitute $h = 0$
			Time = $\frac{625\pi}{3}$ secs or 654 secs (3 sf) oe	**A1**	**3.4**	Allow without secs or 10.9 mins or 10 mins 54 secs or: SC. Use of $r = h\sin 30$ (answer $\frac{625\pi}{4}$ or 491) can score <u>all 4 M-marks and final A1</u>
				[7]		

Question			Answer	Mark	AO	Guidance
8	ctd		**Example method 2**			
			$V = \frac{\pi}{3}r^2\frac{r}{\tan 30^o}$ or $V = \frac{\pi}{\sqrt{3}}r^3$ oe	**B1**		Subst $h = \frac{r}{\tan 30^o}$ into correct formula for V
			$\frac{dV}{dr} = \sqrt{3}\pi r^2$	**M1**		
			$\frac{dV}{dt} = \sqrt{3}\pi r^2\frac{dr}{dt}$ oe	**M1**		Attempt use chain rule to find $\frac{dV}{dt}$ or $\frac{dr}{dt}$ in terms of t and r
			("$\sqrt{3}\pi r^2\frac{dr}{dt}$" $= -2r\sqrt{3}$ oe)			(Set their $\frac{dV}{dt} = -2r\sqrt{3}$ oe)
			$\pi\int_{\frac{50}{\sqrt{3}}}^{0} r\,dr = -\int_0^t 2\,dt$ oe	**M1**		Attempt separate variables in their equation in terms of r and t only (not V or h). Integral signs not essential
			$\left[\frac{\pi r^2}{2}\right]_{\frac{50}{\sqrt{3}}}^{0} = [-2t]_0^t$ oe	**A1**		Correct integrals, any limits or none
			$-\frac{\pi\times 50^2}{6} = -2t$	**M1**		Substitute correct limits into integrals of the form ar^2 & bt OR substitute $t = 0$ & $r = \frac{50}{\sqrt{3}}$ to find c <u>and</u> substitute $r = 0$
			Time = $\frac{625\pi}{3}$ secs or 654 secs (3 sf) oe	**A1**	**3.4**	Allow without secs or 10.9 mins or 10 mins 54 secs SC. Use of $r = h\sin 30$ (answer 491) can score M4A1

Question			Answer	Mark	AO	Guidance
8	ctd		**Example method 3 (NOT using chain rule)**			**This method is different from the summary method above**
			$V = \frac{\pi}{3}(h\tan 30^{\circ})^2 h$ or $V = \frac{\pi}{3}\left(\frac{h}{\sqrt{3}}\right)^2 h$ oe	**B1**	**3.3**	or $V = \frac{\pi}{9}h^3$ oe
			$h = \sqrt[3]{\frac{9V}{\pi}}$	**M1**		Allow $h = kV^{1/3}$
			$\frac{dV}{dt} = -2 \times \sqrt[3]{\frac{9V}{\pi}}$	**M1**		$\frac{dV}{dt} = -2\times$(their h in terms of V)
			$\sqrt[3]{\frac{\pi}{9}} \int_{\frac{\pi 50^3}{9}}^{0} V^{-1/3} dV = -2[t]_0^t$	**M1**		Attempt separate variables in their equation in terms of V and t only (not h or r). Integral signs not essential
			$\sqrt[3]{\frac{\pi}{9}} \times \frac{3}{2}\left[V^{2/3}\right]_{\frac{\pi 50^3}{9}}^{0} = -2t$	**A1**		Correct integrals, any limits or none
			$-\sqrt[3]{\frac{\pi}{9}} \times \frac{3}{2} \times \left(\frac{\pi 50^3}{9}\right)^{2/3} = -2t$	**M1**		Substitute correct limits into integrals of forms $aV^{2/3}$ & bt OR substitute t=0 & $V = \frac{\pi 50^3}{9}$ to find c and substitute $V = 0$
			Time = $\frac{625\pi}{3}$ secs or 654 secs (3 sf) oe	**A1**		Allow without secs or 10.9 mins or 10 mins 54 secs or: SC. Use of $r = h\sin 30$ (answer $\frac{625\pi}{4}$ or 491) can score all 4 M-marks and final A1

Question			Answer	Mark	AO	Guidance
8	**ctd**		**Example incorrect method** $r = 50/\sqrt{3}$ $V = \frac{\pi}{3} \times 2500 \times \frac{h}{3}$ $\frac{dV}{dh} = \frac{2500\pi}{9}$ $\frac{dV}{dh} = \frac{dV}{dt} \times \frac{dt}{dh}$ $\frac{2500\pi}{9} = -2h\frac{dt}{dh}$ $\frac{dh}{h} = -\frac{18}{2500\pi}dt$	**B0** **M0** **M1** **M1**		
9	**(a)**		Area of 20-30 block ÷ total area $= \frac{110}{750}$ or $\frac{22}{150}$ or $\frac{4.4}{30} = 0.147$ (3 sf) **(AG)**	**M1** **A1** **[2]**	**1.2** **1.1**	attempted, using any units, eg small squares or cm^2 Correct calculation seen and answer 0.147 seen Not any method starting with 0.147, eg 0.147 × 150 = 22.05
9	**(b)**	**(i)**	Roughly bell-shaped	**B1** **[1]**	**2.2b**	or Roughly symmetrical and peaks in middle or has one peak and tails off at each end, or drops off either side All 3 of these must be seen (except "Bell-shaped" scores B1) Not "Shape is like normal curve" Ignore all else
9	**(b)**	**(ii)**	Roughly symmetrical about $x = 40$, or area to left of 40 ≈ area to right of 40 or the peak is at 40 or 40 is in the middle $70 - 40 \approx 3\sigma$, hence $\sigma \approx 10$ or most values within 20 of mean, so $20 \approx 2\sigma$	**B1**	**2.4**	or calculate mean and obtain $\frac{5915}{150}$ or 39.4 Allow 40 has the highest frequency or frequency density Ignore all else or calculate sd and obtain 10.3 Most data is within 6σ

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>AO</th><th>Guidance</th></tr>
<tr><td></td><td></td><td></td><td>or (Area within 40±10)/total eg 510/750
or 102/150 = 0.68 or $\approx \frac{2}{3}$</td><td>B1

[2]</td><td>3.3</td><td>Must see correct fraction and $\approx \frac{2}{3}$, or 68% or 0.68</td></tr>
<tr><td>9</td><td>(c)</td><td></td><td>0.136 (3 sf)</td><td>B1
[1]</td><td>1.1</td><td>BC</td></tr>
<tr><td>9</td><td>(d)</td><td></td><td>m = 39.4 or $\frac{5915}{150}$ or $\frac{1183}{30}$,
s = 10.3 (3 sf) or s^2 =106 (3 sf)

0.150 or 0.151 or 0.152 (3 sf) Allow 0.15</td><td>B1
B1

B2
B1

[4]</td><td>3.1a
1.1

3.4
1.1</td><td>Allow 39.1 $\leq m \leq$ 39.7 Ignore method BC
Allow 105.5$\leq s^2 \leq$ 108.5 or 10.27$\leq s \leq$ 10.42 Ignore method
(Use of denominator n or $(n-1)$ is OK for full marks)
<u>OR</u> if neither mark scored,
M1 for attempting find frequencies or areas (NOT heights)
or at least five of these seen: 4, 22, 23, 28, 29, 22, 20, 2
or 20, 110, 115, 140, 145, 110, 100, 10

cao Correct with unclear or no working; B1B1B1B1
or B1 for 0.145 to 0.158

NB No retrospective marks if 0.151 seen in table for (e)(i)</td></tr>
<tr><td>9</td><td>(e)</td><td>(i)</td><td>
<table>
<tr><td>x</td><td>< 20</td><td>20 to 30</td><td>30 to 35</td><td>35 to 40</td><td>40 to 45</td><td>45 to 50</td><td>50 to 60</td><td>> 60</td></tr>
<tr><td>Histogram</td><td>0.027</td><td>0.147</td><td>0.153</td><td>0.187</td><td>0.193</td><td>0.147</td><td>0.133</td><td>0.013</td></tr>
<tr><td>N(40, 100)</td><td>0.023</td><td>0.136</td><td>0.150</td><td>0.191</td><td>0.191</td><td>0.150</td><td>0.136</td><td>0.023</td></tr>
<tr><td>N(m, s^2)</td><td>0.030</td><td>0.151</td><td>0.153</td><td>0.189</td><td>0.183</td><td>0.142</td><td>0.130</td><td>0.023</td></tr>
</table>
</td><td>B1
B1
[2]</td><td>1.1
3.4</td><td>No FT

B1 for middle row correct ±0.001 NB
B1 for bottom row correct ±0.003 NB</td></tr>
<tr><td>9</td><td>(e)</td><td>(ii)</td><td>Nina's model better fit for lower values of X
Nina's model better fit for any ranges < 40
Nina’s model less good fit for 40-45 (or >60)

Sam's model better fit for higher values
Sam's model better fit for any ranges > 40
Sam’s model less good fit for 20-30 (or >60)</td><td>B1

B1</td><td>3.5a

3.5a</td><td>Allow “more accurate” or “less accurate” or similar

BUT SC: “Both less good fit for >60” alone: B1 only
NOT “Both are fairly good fit” B0B0</td></tr>
</table>

Question			Answer	Mark	AO	Guidance
				[2]		Ignore all else **NB No ft**
10	**all**					Allow "percentage" or "value" or "number" or "rate" etc for proportion in all parts of qu 10
10	**(a)**	**(i)**	High(er) or increased proportion 18–24	**B1** [1]	**2.2b**	eg "many 18-24" Ignore any LA mentioned Ignore extras only if they don't contradict High 18-24 only
10	**(a)**	**(ii)**	High(er) or increased proportion either/both	**B1** [1]	**2.2b**	or high proportion of younger. Ignore any LA mentioned Ignore extras
10	**(a)**	**(iii)**	Low(er) or decreased proportion either/both	**B1** [1]	**2.2b**	or low proportion of younger. Ignore any LA mentioned eg "LA F because low % in younger ages" B1 Ignore extras
10	**(b)**	**(i)**	G, H, K, M	**B1** [1]	**2.2b**	No extras or omissions
10	**(b)**	**(ii)**	F, N, R	**B1** [1]	**2.2b**	No extras or omissions
10	**(c)**		Imply need to consider other age range(s) Examples: May be a large % of 25-64 (or 65+) Some LAs have low 0-17 and 18-24 and 65+ Low 0-17 & 18-24 does not mean high 65+ Need to consider other factors or anomalies	**B1** [1]	**2.3**	Low 0-17 & 18-24 not ⇒ attractive to older High % of young people does not necessarily imply low % of older people Older people may want live near young relatives Eg May be reasons for low % younger people eg no schools
10	**(d)**		State all 3 LAs are > 1.5×IQR above UQ Confirms F, N, R (implied) despite (c)	**B1** **B1** [2]	**1.2** **2.2a**	NB. No ft for either mark Or 16.76 + 1.5×(16.76 − 14.56) (= 20.06) Ignore attempt at lower limit Independent mark. But must mention (c)

Question			Answer	Mark	AO	Guidance
10	**(e)**		Mean > UQ Median better	**B1*** **B1dep** **[2]**	**1.1** **2.2b**	or mean is in 4th quartile Ignore all else Not Mean skewed by F, N, R so median better Not Median not skewed by F, N, R so better Not Mean because need take account of outliers (or F,N,R)
11			**See the exemplars at the end of the MS** **Hypotheses:** H_0: $\mu = 3300$ H_1: $\mu > 3300$ where μ = (population) mean mass **Calculation and comparison** $\bar{X} \sim N(3300, \frac{450^2}{200})$ or N(3300, 1012.5) oe and $\bar{X} > 3360$ P($\bar{X} > 3360$) = 0.0297 **(NB 3 sf)**	 **B1** **B1** **M1*** **A1**	 **1.1** **2.5** **3.3** **3.4**	**NB. Use of a "continuity correction" loses 1st A1 only** Allow other letter (including X) only if clearly defined Subtract B1 for each error eg: 2-tail B1B0 Undefined μ B1B0 not in terms of parameter B1B0 Not include 3300 B0B0 $\bar{X}$ stated or implied B0B0 H_0 = 3300 etc: B0B0 μ = sample mean implied B0 & (B1or B0) Correct distribution and $\bar{X}$ (allow 3359.5, 3360.5, 3659) stated or implied eg by 0.0297 or 0.0307 or 0.0286 even if within incorrect statement eg P(X = 3360) = 0.0297 Allow $450^2 \div \sqrt{200}$ or $450^2 \div 200^2$ Not 0.0297 from μ = 3360, P($\bar{X} < 3300$) **BC cao**

Question			Answer	Mark	AO	Guidance
			0.0297 > 0.025	**A1**	**1.1**	Explicit comparison Allow compare (**any value $\underline{\leq}$ 0.35**) with 0.025
11	**ctd**		**Alternative method 1 for M1A1A1:** $\overline{X} \sim N(3300, \frac{450^2}{200})$ and $\overline{X} = 3360$	**M1***		Correct distribution and $\overline{X}$ (allow $\overline{X} = 3359.5$ or 3360.5) stated or implied eg by 0.970 or 0.969 or 0.971 even if within incorrect statement eg $P(X = 3360) = 0.970$ Allow $450^2 \div \sqrt{200}$ or $450^2 \div 200^2$
			$P(\overline{X} < 3360) = 0.970$ **(NB 3 sf)** $0.970 < 0.975$	**A1** **A1**		**BC cao** Explicit comparison Allow compare (**any value $\underline{\geq}$ 0.65**) with 0.975
			Alternative method 2 for M1A1A1: $\frac{a-3300}{450\div\sqrt{200}} = 1.96$ CR, $a = 3362$ **(NB 4 sf)** $3360 < 3362$ or 3360 is in acceptance region	**M1*** **A1** **A1**		May be implied, eg by 3362 Allow $450^2 \div \sqrt{200}$ or $450^2 \div 200^2$ Explicit comparison of their a with 3360
			Alternative method 3 for M1A1A1: $\frac{3360-3300}{450\div\sqrt{200}}$ CV of $z = 1.886$ or 1.89 **(NB 3 sf)** 1.89 (or 1.90 or 1.9) < 1.96	**M1*** **A1** **A1**		Allow 3359.5 or 3360.5 May be implied, eg by 1.89 Allow $450^2 \div \sqrt{200}$ or $450^2 \div 200^2$ **cao** Explicit comparison

Question			Answer	Mark	AO	Guidance
11	ctd		**Conclusion** Not reject H_0	**M1 dep**	**1.1**	Allow Reject H_1 or Accept H_0 Dep M1A1A1 or M1A0A1 or M1A1A0 Dep also on comparing like with like, eg not 0.970 > 0.025 May be implied by their conclusion, if M1 criterion is met ft with opposite conclusion if, eg P($\bar{X}$ > 3360) = 0.024
			There is insufficient evidence that (mean) mass (or mean) is > 3300 (g) or has increased	**A1f**	**2.2b**	Dep M1A1A1 or M1A0A1 or M1A1A0 In context, not definite; eg not "Mean mass not > 3300 g" Not "There is evidence that mean mass hasn't increased" Not "This suggests that mean mass hasn't increased" Not "Unlikely (or unsure) that mean has increased" ft with opposite conclusion if, eg P($\bar{X}$ > 3360) = 0.024
						Alternative scheme for incorrect method using 2-tails: Hypotheses **B1B0** Calculation: as above **M1A1** Compare 0.0125 oe **A1** Conclusion **M0A0**
				[7]		
12	**(a)**		$X \sim B(600, 0.02)$	**M1**	**3.3**	soi, eg H_0: $p = 0.02$ and B(600, p). Allow $n = 600$, $p = 0.02$
			Attempt P($X \geq n$) for $17 \leq n \leq 20$	**M1**	**2.1**	May be implied by 0.0991 or 0.0202 or 0.9798 or 0.9009 or correct values
			(P($X \geq 18$) =) 0.0610 or 0.061 **(2 sf)**	**A1**	**3.4**	or (P($X \leq 17$) =) 0.939 or 0.94 **(2 sf)**
			(P($X \geq 19$) =) 0.0359 or 0.036 **(2 sf)**	**A1**	**1.1**	or (P($X \leq 18$) =) 0.964 or 0.96 **(2 sf)** These two probabilities seen imply M1M1A1A1 Condone errors such as P($X > 18$) = 0.0610
			P(concludes claim incorrect) = 0.0359 **(3 sf)**	**A1**	**2.2a**	Ignore hypotheses and/or "Reject H_0" or similar

Question			Answer	Mark	AO	Guidance
				[5]		Unsupported answers; 0.0359: M1M1A1A0A0 Critical region is $X \geq 19$ M1M1A0A0A0
12	(a)	ctd	**Alternative method (normal with no cc)** $X \sim N(600\times0.02, 600\times0.02\times0.98)$ or $X \sim N(12, 11.76)$ Attempt $P(X \geq n)$ for $17 \leq n \leq 20$ $P(X \geq 17) = 0.0724$ or 0.072 **(2 sf)** $P(X \geq 18) = 0.0401$ or 0.040 **(2 sf)** P(concludes claim incorrect) = 0.0401	 **M1** **M1** **A1** **A1** **A0**		 soi. Can be scored either for N(12, 11.76) or B(600, 0.02) $P(x > a) = 0.05 \Rightarrow a = 17.64$ only gets M1 if a probability is calculated
			Alternative method (normal with cc) $X \sim N(600\times0.02, 600\times0.02\times0.98)$ or $X \sim N(12, 11.76)$ Attempt $P(X \geq n)$ for $17 \leq n \leq 20$ $P(X \geq 18) = P(X \geq 17.5) = 0.054$ **(2 sf)** $P(X \geq 19) = P(X \geq 18.5) = 0.0290$ **(2 sf)** P(concludes claim incorrect) = 0.0290	 **M1** **M1** **A1** **A1** **A0**		 soi. Can be scored either for N(12, 11.76) or B(600, 0.02)
12	(b)		(Incorrect because eg:) You have to consider $P(X \geq 18)$ or18 is in the acceptance region (for 5% test) or critical region is ≥ 19, or CV is 19	 **B1** **[1]**	 **2.3**	 or 18 is under the significance level Allow You have to do a proper hypothesis test No other answers acceptable
13	(a)		Single Venn diagram drawn showing 3, 14, x and $3x$ correctly placed $3 + 14 + x + 3x = 25$ oe or $x = 2$ Number who study English = "2" + 3 or 5	**B1** **M1** **M1**	**3.1a** **1.1a** **1.1**	or showing 3, 14, 2 and 6 correctly placed Allow omission of rectangle, so long as 14 seen outside Allow probabilities in the diagram May be implied, eg by 2 seen in correct place in diagram Their $x + 3$. May be implied by answer

Question			Answer	Mark	AO	Guidance
			P(E) = $\frac{5}{25}$ or $\frac{1}{5}$ or 0.2	**A1**	**1.1**	
				[4]		If x is total English, giving $x = 5$, use an equivalent scheme.
13	**(a)**	**ctd**	**Alternative (incorrect) method for H↔E**			
			Diagram	**B0**		
			$3 + 14 + x + 3x = 25$ oe or $x = 2$	**M1**		Or implied in diagram, History only = 2, or total History= 5
			Number who study English = "6" + 3 or 9	**M1**		Their $3x + 3$. May be implied by answer
			P(E) = $\frac{9}{25}$	**A1**		If x is total History, giving $x = 5$, use an equivalent scheme
13	**(b)**		P(exactly one English) = $\frac{5}{25}\times\frac{20}{24}$ ×2 oe	**M1**	**1.1**	Allow omit ×2. Allow $\frac{5}{25}\times\frac{20}{25}$ or 0.16 or 0.32. Allow + ….
			= $\frac{1}{3}$ or 0.333 (3sf)	**A1**	**1.1**	NB No ft from (a) in (b)
			P(exactly one E and exactly one H) = P(HE′ and H′E) + P(EH and E′H′)			
			= ($\frac{6}{25}\times\frac{2}{24}$ + $\frac{3}{25}\times\frac{14}{24}$) ×2 oe	**M2**	**3.1b**	M1 for one of $\frac{6}{25}\times\frac{2}{24}$ or $\frac{3}{25}\times\frac{14}{24}$ oe
					2.4	OR $\frac{6}{25}\times\frac{2}{25}$ + $\frac{3}{25}\times\frac{14}{25}$ (both terms)
			(= $\frac{9}{50}$ or 0.18)			OR $\frac{6}{25}\times\frac{a}{24}+\frac{3}{25}\times\frac{b}{24}$ or $\frac{2}{25}\times\frac{a}{24}+\frac{14}{25}\times\frac{b}{24}$ (a,b integer < 24)
						Allow any of the above + extras for M1
			$\frac{\text{P(exactly one E and exactly one H)}}{\text{P(exactly one E)}}$ (= $\frac{9}{50}\div\frac{1}{3}$)	**M1**	**1.1**	Divide attempted probs of correct events dep ≥ M1M1
			= $\frac{27}{50}$ or 0.54 (3 sf) cao	**A1**	**1.1**	Careful!! SCs for correct answer by incorrect methods:
						"×2" omitted throughout:
						$\frac{9}{100}\div\frac{1}{6}=\frac{27}{50}$: M1A0M1M0M1A1 (Total 4)
						Denominator 25×25 instead of 25×24:

Question			Answer	Mark	AO	Guidance
				[6]		$\frac{54}{625} \div \frac{4}{25} = \frac{27}{50}$: M1A0M1M0M1A1 (Total 4) Both the above $\frac{27}{625} \div \frac{2}{25} = \frac{27}{50}$ M1A0M1M0M1A1
13	(b)	ctd	**Alternative method 1:** n(exactly one English) = n(E) × n(E′) = 5 × 20 = 100 n(exactly one E and exactly one H) = n(EH′) × n(E′H) + n(EH) × n(E′H′) = 2×6 + 3×14 (= 54) Attempt $\frac{\text{n(exactly one E and exactly one H)}}{\text{n(exactly one E)}}$ $(= \frac{54}{100})$ = $\frac{27}{50}$ oe or 0.54 (3 sf) cao	**M1** **A1** **M1** **M1** **M1** **A1**		M1 for one of 2×6 or 3×14 or M1 for 2×*a* + 3×*b* (*a*, *b* integers, *a* < 23, *b* < 22)
			Alternative method 2 P(H/E) = 3/5 P(H/E') = 6/20 P(H'/E) = 2/5 P(H'/E') = 14/20 6/20×2/5 + 3/5×14/20 = 27/50	**M1** **A1** **M3** **A1**		M1 for three of these fractions seen A1 for all four fractions seen M2 for one of these products 6/20×2/5 or 3/5×14/20 or M1 for *a*/20×2/5 + 3/5×*b*/20 or M1 for 6/*a*×2/5 + 3/5×14/*b*

Question			Answer	Mark	AO	Guidance
13	(b)	ctd	**Alternative (incorrect) method for H↔E**			
			P(exactly one English) = $\frac{9}{25}\times\frac{16}{24}$ (×2)	**M1**		Allow without ×2. Allow $\frac{9}{25}\times\frac{16}{25}$ or 0.230 or 0.461.
			= $\frac{6}{25}$	**A0**		
			P(exactly one E and exactly one H) = P(HE′ and H′E) + P(EH and E′H′)	**M1**		
			Same as main scheme	**M1**		
			(= $\frac{9}{50}$ or 0.18)			
			$\frac{\text{P(exactly one E and exactly one H)}}{\text{P(exactly one E)}}$	**M1**		Attempt divide attempted probabilities of correct events dep at least M1M1
			(= $\frac{9}{50} \div \frac{6}{25}$)			
			= $\frac{3}{4}$ or 0.75 (3 sf)	**A0**		SC answer $\frac{3}{4}$, but omit ×2 and/or denominator of 25, M1A0M1M0M1A1

Exemplars for Q11

Hypotheses

A	H_0: $\mu = 3300$ H_1: $\mu > 3300$ where μ = (pop) mean mass	 B1B1
B	H_0: $\mu = 3300$ H_1: $\mu > 3300$	 B1B0
C	H_0: The (pop) mean mass is 3300 H_1: The (pop) mean mass is greater than 3300 See Specimen paper q10 MS "Must be in terms of parameter values"	 B1B0
D	$H_0 = 3300$ $H_0 > 3300$	 B0B0
E	H_0: $\mu = 3300$ H_1: $\mu \neq 3300$ where μ = (pop) mean mass	 B1B0
F	H_0: $\mu = 3300$ H_1: $\mu \neq 3300$	 B0B0

Calculation, comparison and conclusion

G	No statement of distribution $P(\bar{X} = 3360) = 0.0297$ $0.0297 > 0.025$ Don't reject H_0 There is no evidence that mean mass has increased	 M1A1 A1 M1 A1
H	$P(\bar{X} = 3360.5) = 0.0286$ $0.0286 > 0.025$ Accept H_0 There is evidence that mean mass hasn't increased	M1A0 A1 M1 A0
I	$P(\bar{X} > 3360.5) = 0.0286$ Accept H_0 There is evidence that mean mass hasn't increased	M1A0 A0 M1 A0
J	$P(\bar{X} = 3359.5) = 0.024$ $0.024 < 0.025$ Reject H_0 There is evidence that mean mass has increased	M1A0 A1 M1 A1ft
K	$P(\bar{X} < 3360) = 0.970$ $0.970 < 0.975$ Reject H_1 Insufficient evidence that mean mass has changed	M1A1 A1 M1 A0
L	$P(\bar{X} > 3360) = 0.970$ $0.970 > 0.025$ Insufficient evidence that mean mass has increased	M1A1 A0 M0A0

M	$\overline{X} \sim N(3300, 1012.5)$	
	$P(\overline{X} > 3360) = 0.297$	M1A0
	$0.297 > 0.025$	A1
	Insufficient evidence that mean mass has increased	M1A1
N	$\mu \pm 1.96\sigma$ = 3237 to 3362	M1A1
	3360 lies within this range	A1
	Can't reject H_0	M1
	Mean mass hasn't increased	A0
O	CV = 3362	M1A1
	3360 < 3362	A1
	Reject H_0. Evidence that level of poll't has increased.	M0A0
P	$(3360 - 3300) \div (450 \div \sqrt{200}$ = 1.886	M1A1
	1.866 < 1.96	A1
	Don't reject H_0. Mean mass hasn't increased.	M1A0

2-tail

Q	H_0: $\mu = 3360$	
	H_1: $\mu \neq 3360$	B0B0
	0.0297 > 0.0125	A1
	Don't reject H_0	M0
	There is no evidence that mean mass has changed	A0
R	H_0: $\mu = 3360$	
	H_1: $\mu \neq 3360$ where μ = (pop) mean mass	B1B0
	0.0297 > 0.025	A0
	Don't reject H_0	M0
	There is no evidence that mean mass has changed	A0
S	H_0: The (pop) mean mass = 3360	
	H_1: The (pop) mean mass ≠ 3360	B0B0
	0.97 < 0.9875	A1
	Accept H_0	M0
	There is no evidence that mean mass has changed	A0

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