OCR
Oxford Cambridge and RSA

GCE

Mathematics A

Unit **H240/02**: Pure Mathematics and Statistics

Advanced GCE

Mark Scheme for June 2018

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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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Annotations and abbreviations

Annotation in scoris	**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
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 *
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 for A Level Mathematics A

a Annotations should be used whenever appropriate during your marking. The A, M and B annotations must be used on your standardisation scripts for responses that are not awarded either 0 or full marks. It is vital that you annotate standardisation scripts fully to show how the marks have been awarded. For subsequent marking you must make it clear how you have arrived at the mark you have awarded.

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 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
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
Mark for explaining a result or establishing a given result. 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. This rule should be applied to each case. When a value is not given in the paper accept any answer that agrees with the correct value to 2 s.f. Follow through should be used so that only one mark is lost for each distinct accuracy error, except for errors due to premature approximation which should be penalised only once in the examination. There is no penalty for using a wrong value for g. E marks will be lost except when results agree to the accuracy required in the question.

g Rules for replaced work: if a candidate attempts a question more than once, and indicates which attempt he/she wishes to be marked, then examiners should do as the candidate requests; if there are two or more attempts at a question which have not been crossed out, examiners should mark what appears to be the last (complete) attempt and ignore the others. NB Follow these maths-specific instructions rather than those in the assessor handbook.

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 mark in the question. Marks designated as cao may be awarded as long as there are no other errors. E marks are lost unless, by chance, the given results are established by equivalent working. 'Fresh starts' will not affect an earlier decision about a misread. 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, of course, that there is nothing in the wording of the question specifying that analytical methods are required). 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.

Final Version

Question			Answer	Mks	AO	Guidance	
1	(i)		$2(x^2 - 6x + 11.5)$ $2((x-3)^2 + 11.5 - 9)$ $2(x-3)^2 + 5$	**B1** **B1** **M1** **A1** **[4]**	**1.1a** **1.1** **1.1** **1.1**	or $a = 2$ or $b = -3$ $23 - 2(\text{their } b)^2$ or $c = 5$	
1	(ii)		$2(x+3)^2 + 5$ is always +ve or $2(x+3)^2 + 5 > 0$ or $2(x+3)^2 + 5 \geq 5$ Hence no real roots	 **B1f** **[1]**	 **1.1**	or $2(x+3)^2 = -5$, which is impossible or "+ve quadratic" and min on $y = 5$ or "+ve" quadratic; TP at (3, 5). Both Hence no real roots Must use (i), not use D	$2(x+3)^2 + 5 = 0$ $\Rightarrow x = \sqrt{\text{neg}}$ or $x + 3 = \sqrt{\text{neg}}$ ft their (i) (a & $c > 0$)
1	(iii)		$2(x-3)^2 = 2(x^2 - 6x + 9)$ $k = 18$	**M1** **A1** **[2]**	**1.1a** **2.2a**	or $12^2 - 8k = 0$	
2	(i)		$(1-(-3))^2 + (-2-(-1))^2 + (5-2)^2$ (= 26) Length = $\sqrt{26}$ or 5.10 or 5.1 (2 sf)	**M1** **A1** **[2]**	**1.1a** **1.1**	Attempt. Allow with one sign error	√ not nec'y
2	(ii)		$\begin{pmatrix} -1 \\ -1.5 \\ 3.5 \end{pmatrix}$	 **B1** **[1]**	 **1.1**		
2	(iii)		$\overrightarrow{BA} = \begin{pmatrix} 4 \\ -1 \\ 3 \end{pmatrix}$ $\overrightarrow{PQ} = \begin{pmatrix} 5 \\ 1 \\ 3 \end{pmatrix} - \begin{pmatrix} 1 \\ 2 \\ 0 \end{pmatrix} \quad \left(= \begin{pmatrix} 4 \\ -1 \\ 3 \end{pmatrix}\right)$ $BA = PQ$ and $BA \parallel PQ$ and hence $ABPQ$ is a parallelogram **(AG)**	**M1** **M1** **A1** **[3]**	**2.1** **1.1** **2.2a**	or quote result for $\overrightarrow{BA}$ from **(ii) or (i)(a)** or similar methods with AQ & BP or AB and QP etc Allow find eg AB and PQ or $\overrightarrow{BA} = \overrightarrow{PQ}$ with arrows or $\lvert BA\rvert = \lvert PQ\rvert$ & $\lvert BP\rvert = \lvert AQ\rvert$ shown & stated or $BA \parallel PQ$ & $BP \parallel AQ$ shown & stated Both statements needed, dep M1M1	SC Incorrect, but equal, vectors BA & PQ with correct conclusion SC B1 Allow without method SC Lengths only seen: M1M0 Just $\lvert BA\rvert = \lvert PQ\rvert$ A0

Question			Answer	Mks	AO	Guidance	
3	(i)		7 hours	B1 [1]	2.2b	Allow between 6 and 8 hours.	
3	(ii)		Dave will gain no marks even if he does no revision	B1 [1]	3.5a	oe	
3	(iii)		(Bob believes) too much revision leads to tiredness (or less sleep or stress or forgetting) and hence a lower mark. (Ayesha does not.)	B1 [1]	3.5a	oe Must suggest reason for drop in marks	
3	(iv)		(She believes that) however much or little revision she does it will make no difference to the mark she obtains	B1 [1]	2.2b	or (She thinks) revision will not increase her mark or revision is unnec'y to obtain high mark	revision is unhelpful oe
4			<u>Summary of method</u> Use of $\cos(A+B)$ or $\sin(A+B)$ or $\cos 2\theta$ formula Correct result Use of one of the above or $\sin 2\theta$ formula Correctly obtain result <u>Example of method</u> $\sin^2(\theta+45) - \cos^2(\theta+45) \equiv -\cos 2(\theta+45)$ $\equiv -\cos(2\theta+90)$ $\equiv -[\cos 2\theta \cos 90 - \sin 2\theta \sin 90] \equiv \sin 2\theta$ **AG**	 M1 A1 M1 A1 M1 A1 M1 A1 [4]	 3.1a 2.1 1.1 1.1 	 Correct formula Correct formula <u>Use</u> of correct $\cos 2\theta$ formula Correct result <u>Use</u> of correct $\cos(A+B)$ formula Must see this step and final answer	
5	(i)		eg $1 + 3 = 4$ or $4 + 5 = 9$ or $9 + 7 = 16$	B1 [1]	1.1	or $25 + 11 = 36$ or any correct example	
5	(ii)		If $m - n = 1$ (or -1) then $(m-n)(m+n)$ could be prime	E1 [1]	2.3	or One of the factors of p could be 1	(or if $m + n = 1$)
5	(iii)		Let $S = n^2$ $\Rightarrow$ Other square number is $(n+1)^2$ $\Rightarrow 853 = (n+1)^2 - n^2 = 2n + 1$ $\Rightarrow n = 426$	 M1 M1 A1	 3.1a 2.2a 1.1	 or Other square number is $(\sqrt{S}+1)^2$ $\Rightarrow 853 = (\sqrt{S}+1)^2 - S = 2\sqrt{S} + 1$ $\Rightarrow \sqrt{S} = 426$	$853 = m^2 - n^2$ & $m - n = 1$ $\Rightarrow 853 = m + n$ $\Rightarrow 853 = 2n + 1$ $\Rightarrow n = 426$

Question			Answer	Mks	AO	Guidance	
			$\Rightarrow S = 181476$	**A1** **[4]**	**3.2a**	$\Rightarrow S = 181476$ $m - n = 1$, $m + n = 853$ M1 $2m = 854$ M1 $m = 427$ $n = 426$ A1 $n^2 = 181476$ A1	$\Rightarrow S = 181476$ T & I: 426 seen M1M1A1 $S = 181476$ A1
6			**DR**				
6	**(i)**		$\frac{\ln x}{x} = 0$ $\Rightarrow \ln x = 0$ or $\frac{\ln 1}{1} = 0$ $\Rightarrow x = 1$	 **M1** **A1** **[2]**	 **1.1a** **1.1**	May not be seen May be implied	
6	**(ii)**		y-coordinates are $\frac{\ln 2}{2}$ and $\frac{\ln 4}{4}$ $\frac{\ln 4}{4} = \frac{2\ln 2}{4} = \frac{\ln 2}{2}$ oe $\Rightarrow AB$ is // to x-axis **AG**	 **B1*** **B1dep*** **[2]**	 **1.1** **3.1a**	 Allow $\frac{\ln 4}{4} = \ln 4^{\frac{1}{4}} = \ln\sqrt{2} = \frac{\ln 2}{2}$ Show that $\frac{\ln 4}{4} = \frac{2\ln 2}{4}$ and conclusion	 Both = 0.346... B0B0 use of $\frac{\ln 4}{4} - \frac{\ln 2}{2} = 0$ unjustified B0B0
6	**(iii)**		$\frac{dy}{dx} = \frac{x\times\frac{1}{x} - 1\times\ln x}{x^2}$ or $\frac{1}{x}\times\frac{1}{x} + \ln x \times (-\frac{1}{x^2})$ oe $\frac{1}{x^2} - \frac{\ln x}{x^2} = 0$ or $\frac{1-\ln x}{x^2} = 0$ $1 - \ln x = 0$ oe $x = $ e or 2.72 or 2.7 (2 sf) Coordinates are $(e, \frac{1}{e})$	**M1** **M1** **A1** **A1** **[4]**	**3.1a** **1.1** **1.1** **1.1**	Attempt diff, $\geq$ one term correct oe, their $\frac{dy}{dx} = 0$ Allow (e, 0.368) or (e, 0.37)	 or (2.7, 0.37) (2 sf)

Question			Answer	Mks	AO	Guidance	
6	(iv)		Attempt $\frac{d^2y}{dx^2}$	M1	2.1	Attempt diff their $\frac{dy}{dx}$	Example of grad method Sub 2.7 & 2.8 in $\frac{dy}{dx}$ M1
			$= \frac{x^2(-\frac{1}{x})-2x(1-\ln x)}{x^4}$ or $\frac{-3+2\ln x}{x^3}$ oe	A1	1.2	All correct, not necessarily simplified cao	0.00093, –0.0038 A1A1
			Substitute x = e (or 2.72) into $\frac{d^2y}{dx^2}$	M1	1.1	Sub their x from (iii) into their $\frac{d^2y}{dx^2}$	State grad +ve & -ve or show on diag dep A1A1 M1
			$\frac{d^2y}{dx^2} = -\frac{1}{e^3}$ oe or –0.0498	A1	1.1	cao Allow or – 0.0497 or –0.05	
			$\frac{d^2y}{dx^2} < 0$, hence maximum	B1f	3.2a	ft their result of sub their x into their $\frac{d^2y}{dx^2}$ dep see result	Hence max B1f dep M1A1A1 No proof, no marks
				[5]			
7			**Summary of marks:**				
			Attempt find x at intersection of curves	M1	3.1a	Can be implied	
			$x = 1$	A1	1.1		
			Correct integral, any limits	M1	3.1a		
			Correct numerical result	A1	1.1	from correct limits	
			Attempt area of part or all of 2×2 square	M1	1.1		
			Wholly correct method	M1	2.1		
			$\frac{44}{3}$	A1	1.1		
				[7]			

Question	Answer	Mks	AO	Guidance	
	Examples of methods:				
	Method 1				
	$3 - 2x^2 = x$	**M1**			or $3 - 2x^2 = -x$
	$2x^2 + x - 3 = 0$				$2x^2 - x - 3 = 0$
	$x = 1$	**A1**		Ignore other root	$x = -1$
	$\int_0^1 (3 - 2x^2)\mathrm{d}x$ or $\int_{-1}^1 (3 - 2x^2)\mathrm{d}x$	**M1**		Correct integrand with any limits	
	$= \left[3x - \frac{2x^3}{3}\right]_0^1$ or $\left[3x - \frac{2x^3}{3}\right]_{-1}^1$				
	$= \frac{7}{3}$ or $\frac{14}{3}$	**A1**			
	$"\frac{7}{3}" - 1 \left(= \frac{4}{3}\right)$ or $"\frac{14}{3}" - 2 \left(= \frac{8}{3}\right)$	**M1**		Attempt area above $y = 1$ or above $y = x$	or $"\frac{14}{3}" - 1 \left(= \frac{11}{3}\right)$
	$8 \times "\frac{4}{3}" + 4$ or $4 \times "\frac{8}{3}" + 4$	**M1**		Complete correct method	$4 \times \frac{11}{3}$
	$= \frac{44}{3}$	**A1**			
	Method 2			Method 3	
	$3 - 2x^2 = x$	**M1**		$3 - 2x^2 = x$	
	$x = 1$	**A1**		$x = 1$	
	$\int_1^3 \left(\frac{y-3}{2}\right)^{\frac{1}{2}} \mathrm{d}y$	**M1**		$\int_0^1 (3 - 2x^2 - 1)\mathrm{d}x$	
	$= .....$			$= \left[2x - \frac{2x^3}{3}\right]_0^1$	
	$= \frac{4}{3}$	**A1**		$= \frac{4}{3}$	
	$\frac{4}{3} + \frac{1}{2} \left(= \frac{11}{6}\right)$	**M1**		$\frac{4}{3} + \frac{1}{2} \left(= \frac{11}{6}\right)$	
	$8 \times \frac{11}{6}$	**M1**		$8 \times \frac{11}{6}$	
	$= \frac{44}{3}$	**A1**		$= \frac{44}{3}$	Other correct methods may be seen

Question			Answer	Mks	AO	Guidance	
8	(i)	(a)	0.0478 or 0.048 (2 sf)	B1 [1]	1.1	**BC**	
	(i)	(b)	22.5 or 23 (2 sf)	B1 [1]	1.1	**BC**	
	(i)	(c)	$P(X < 20 + b) = 0.75$ or $P(X > 20 + b) = 0.25$ $20 + b = 22.02..$ or 22.0 or 22 $b = 2.02$ or 2.0 (2 sf) Allow $b = 2$	M1 A1 A1 [3]	1.1a 1.1 1.1	$P(X < 20 - b) = 0.25$ $20 - b = 17.98$ or 18 $b = 22(.02)$ M1A1A0 T & I method: Try 2 values, one ≈ 2 M1 Correct probs for two values in [2, 2.1] A1 Correct probs for two values in [2, 2.05] & ans 2.0 or 2 A1	 (0.495 & 0.516)
8	(ii)		$\frac{1.5\mu-\mu}{\mu/3}$ $= \frac{3}{2}$ $P(X > 1.5\mu) = 0.0668$ or 0.67 (2 sf)	M1 A1 A1 [3]	1.1a 1.1 1.1	$\frac{4.5\sigma-3\sigma}{\sigma}$	SC (eg) Let $\mu = 1$; $N(1, \frac{1}{9})$ M1 $X = \frac{3}{2}$ A0 $P(X > \frac{3}{2}) = 0.067$ A1
9			$H_0: p = \frac{1}{6}$ $H_0: p > \frac{1}{6}$ where p = P(2 on one throw) $B(35, \frac{1}{6})$ $P(X \geq 10) = 1 - P(X \leq 9)$ or $P(X \geq 11) = 1 - P(X \leq 10)$ $P(X \geq 10) = 0.055$ $P(X \geq 11) = 0.023$ (0.04 lies between these hence) rejection region is $X \geq 11$ Allow eg $a \geq 11$ Special case, using N~Bin; Method A $H_0: \mu = \frac{35}{6}$	B1 B1 M1 M1 A1 A1 A1 B1	1.1 2.5 3.3 1.1a 2.1 3.4 2.2a 1.1	 **B1B0** one error eg undefined p or two-tail stated or implied unless clearly using N( ) $\geq$ 1 of these probabilities stated **BC** **BC** dep ≥ one of above probs seen & correct 	 or $P(X \leq 9)$, $P(X \leq 10)$ $P(X \leq 9) = 0.945$ $P(X \leq 10) = 0.977$ (0.96 between these) rej'n region is $X \geq 11$

Question			Answer	Mks	AO	Guidance	
			$H_0: \mu > \frac{35}{6}$ where μ = pop mean no. of 2's	**B1**	**2.5**	**B1B0** one error eg undefined μ or two-tail	
			$N(\frac{35}{6}, \frac{175}{36})$ or N(5.833, 4.861) soi	**M1**	**3.3**	Allow incorrect variance	
			$P(X \geq 10) = 1 - P(X < 9.5)$ or $P(X \geq 11) = 1 - P(X < 10.5)$	**M1**	**1.1a**	$\geq$ 1 of these probabilities attempted	$P(X < 9.5)$ or $P(X < 10.5)$
			$P(X \geq 10) = 0.048$	**A0**	**2.1**	**BC**	$P(X < 9.5) = 0.952$
			$P(X \geq 11) = 0.017$	**A1**	**3.4**	**BC**	$P(X < 10.5) = 0.983$
			(0.04 lies between these hence) rejection region is $X \geq 11$	**A1**	**2.2a**	dep ≥ one of above probs seen & correct	(0.96 between these) rej'n region is $X \geq 11$
			Special case, using N~Bin; Method B				
			$H_0: \mu = \frac{35}{6}$	**B1**	**1.1**		
			$H_0: \mu > \frac{35}{6}$ where μ = pop mean no. of 2's	**B1**	**2.5**	**B1B0** one error eg undefined μ or two-tail	
			$N(\frac{35}{6}, \frac{175}{36})$ or N(5.833, 4.861) soi	**M1**	**3.3**	Allow incorrect variance	
			$P(X > a) = 0.04$ soi	**M1**	**1.1a**	$z = \phi^{-1}(0.96)$ (= 1.751)	
			$\frac{35}{6} + 1.751 \times \sqrt{\frac{175}{36}}$	**A1**	**2.1**	dep $\phi^{-1}(0.96)$ attempt. May be implied **BC**	
			= 9.69 or 9.7	**A0**	**3.4**		
			rejection region is $X \geq 11$	**A1** **[7]**	**2.2a**		
10	**(i)**		Only 784 trees and 810 > 784	**E1** **[1]**	**2.4**	or other similar	
10	**(ii)**		eg Each no. not independent of previous no. Each no. is related to the next	**E1** **[1]**	**2.3**	Allow 2nd digit of each no. is 1st of next Consecutive nos share two digits Ignore all else	or similar correct Digits are re-used

Question			Answer	Mks	AO	Guidance	
10	(iii)		H_0: $\mu = 4.2$ H_1: $\mu < 4.2$ where μ is mean height of trees (in the wood)	B1 B1	1.1 2.5	Allow other letters except X or $\bar{X}$ One error, eg undefined μ or 2-tail: B0B1	
			$\bar{X} \sim N(4.2, \frac{0.8^2}{50})$ and $\bar{X} < 4.0$ or $\bar{X} \leq 4.0$	M1	3.3	Stated or implied Allow $\bar{X} > 4.0$ or $\bar{X} = 4.0$	$\Phi^{-1}(0.98)$ (= 2.054)
			P($\bar{X} < 4.0$) = 0.038549.... or 0.039	A1	3.4	**BC** Allow 0.038 NB 0.038... implies M1A1	$4.2 - 2.054 \times \frac{0.8}{\sqrt{50}}$ (= 3.968)
			Compare 0.02	A1	1.1	dep P($\bar{X} < 4.0$) attempted	comp their 3.968 with 4.0
			Do not reject H_0	M1	2.2b	Allow Accept H_0 dep P($\bar{X} < 4.0$) attempted	Can be implied by conclusion
			There is insufficient evidence that mean height of these trees in the wood is less than 4.2m.	A1f [7]	3.5a	In context, not definite; eg "Mean height not less than 4.2m": A0	
11	(i)	(a)	Both the number of employees using public transport and the number of employees using private vehicles depend on the LA population.	E1 [1]	2.1	or similar, but must be in context. Ignore all else	NOT No. using pt is prop to no. using pv
11	(i)	(b)	Negative If a large prop use public transport then a smaller	E1ind	2.2b	Ignore "strong" or "slight" etc	NOT Inverse prop'n NOT "as a increases b decreases" unless in context
			prop drive (and vice versa)	E1ind [2]	2.4	or similar in context	
11	(ii)	(a)	Decrease the size of r or Make r less negative	E1 [1]	2.2b	Make (value of) r increase r closer to 0 Ignore eg "greatly" Ignore all else	NOT Make r decrease NOT Weaken the corr'n NOT Make corr'n less
11	(ii)	(b)	Little effect (because the population of the LA is small compared with the whole population)	E1 [1]	2.2b	or No effect or similar Ignore all else	
11	(ii)	(c)	Ignore all reference to public transport <u>Type 1 answers</u> People don't travel far to work Jobs are close High proportion walk (or cycle)	E1 [1]	2.4	<u>Type 2 answers</u> Any suggested <u>reason</u> why few drive eg Few garages; Parking expensive or similar in context	NOT just Few drive

Question			Answer	Mks	AO	Guidance	
12	(i)		$a(1+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16})=1$ soi $a=\frac{16}{31}$	M1 A1 [2]	3.1a 1.1	or $\frac{16}{31}(1+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16})=1$ oe seen correctly obtained	
12	(ii)		P(X = 1, 3 or 5) = $\frac{21}{31}$ 0r 0.677 or 0.68 (2 sf)	B1 [1]	1.1a		
12	(iii)		P(sum odd) = P(OE) + P(EO) $=2\times\frac{21}{31}\times(1-\frac{21}{31})$ $=\frac{420}{961}$ or 0.437 or 0.44 (2 sf)	M1 A1 [2]	2.1 1.1	or correct "long" method	Allow without "2 ×"
12	(iv)		P(Sum > 8 & odd) = P(Sum = 9) = P(4, 5) + P(5, 4) $=\frac{2}{31}\times\frac{1}{31}+\frac{1}{31}\times\frac{2}{31}$ $(=\frac{4}{961})$ $\frac{P(\text{Sum}>8\ \&\ \text{odd})}{P(\text{Sum odd})}$ $='\frac{4}{961}'\div'\frac{420}{961}'$ $=\frac{1}{105}$ or 0.00952 or 0.0095 (2 sf)	M1 M1 A1 [3]	1.1a 2.4 1.1	or P(> 8) × P(O | > 8) $=\frac{5}{961}\times\frac{4}{5}$ Attempt ft their (iii) and their P(Sum > 8 & odd) cao **NB** $\frac{2}{961}\div\frac{210}{961}=\frac{1}{105}$ M0M1A0	Correct method
12	(v)		$S_\infty=\frac{p}{1-0.5}=1$ P(X = 1) = 0.5	M1 A1 [2]	3.4 3.4	 Correct ans, no working M1A1	
12	(vi)		Eg Y. (Y takes all values, but) X cannot be > 5 Eg X because > 5 is very unlikely	B1 [1]	3.5b	oe, eg Y. It may take more than 5 attempts or "limited no." oe instead of 5	

Question			Answer	Mks	AO	Guidance	
13			**DR**				
13	**(i)**		N(450×0.15, 450×0.15×0.85) or N(67.5, 57.375) oe	**M1**	**3.1b**	seen or implied	B(450, 0.15) with T & I method using ≥ one of 74, 75, 76, 61, 60, 59
			$P(Y > \mu + \sigma) \approx \frac{1}{6}$ or $\Phi^{-1}(\frac{1}{6}) = 0.9674$			$P(Y < a) = \frac{5}{6}$	
			'67.5' + $\sqrt{\text{'57.375'}}$ or '67.5' + 0.9674× $\sqrt{\text{'57.375'}}$	**M1**	**1.2**	or 74.83 seen; ft their μ & σ for M1 only	$P(X > 74) = 0.177$ $P(X > 75) = 0.145$ both
			= 74 or 75 or 76	**A1**	**1.1**	Integer. No ft Dep M1M1 Correct ans, inadequate wking: M0M0A0 **NB 450/6 = 75 M0M0A0**	a = 74 or 75 or 76
				[3]			
13	**(ii)**		$\frac{\frac{50!}{r!(50-r)!}\times 0.15^{r}\times 0.85^{50-r}}{\frac{50!}{(r+1)!(50-(r+1))!}\times 0.15^{r+1}\times 0.85^{50-(r+1)}}$ oe	**M1**	**1.1a**	$\frac{{}^{50}C_{r}\times 0.15^{r}\times 0.85^{50-r}}{{}^{50}C_{r+1}\times 0.15^{r+1}\times 0.85^{50-(r+1)}}$	Fully correct
			eg $\frac{\frac{1}{50-r}\times 0.85}{\frac{1}{r+1}\times 0.15}$ or $\frac{0.85}{50-r}\times\frac{r+1}{0.15}$ oe	**A1**	**2.1**	Any correct simplification without factorials **OR** without indices	**or** $\frac{17}{20}\times\frac{20}{3}\times\frac{r+1}{50-r}$
			$= \frac{17(r+1)}{3(50-r)}$ **AG**	**A1**	**1.1**	Any correct simplification without factorials **AND** without indices and correctly obtain result	
				[3]			
13	**(iii)**	**(a)**	$\frac{17(r+1)}{3(50-r)} \le 1$ oe	**M1**	**3.1b**	$\frac{1}{50-r}\times 0.85 \le \frac{1}{r+1}\times 0.15$ oe M1	No factorials or indices
			$17r + 17 \le 150 - 3r$			$0.85(r + 1) \le 0.15(50 - r)$	
			$20r \le 133$ oe	**A1**	**1.1**	$r \le 50\times 0.15 - 0.85$ A1	Correct, in form $ar \le b$ or $r <$ correct expr'n
			$r \le 6.65$	**A1**	**1.1**		
			r is an integer so $r \le 6$	**A1**	**1.1**		
						SC: $P(X=6)=0.142$, $P(X=7)=0.157$, $P(X=8)=0.149$ B1	
						(must be these three) hence $r \le 6$ B1dep	No wking B0B0
				[4]			

Question			Answer	Mks	AO	Guidance	
13	(iii)	(b)	$P(X = r) \leq P(X = r + 1)$ for $r \leq 6$ Hence most likely value is r is 6 or 7				
			$\frac{P(X=6)}{P(X=7)} = \frac{17(6+1)}{3(50-6)} = 0.902 < 1$	**B1**	**2.1**	or $P(X = 6) = 0.142$ & $P(X = 7) = 0.157$	NOT 6.65 rounds to 7 B0B0
			Most likely value is 7	**B1**	**3.2a**	indep, but dep on some reasonable explanation	No expl'n: B0B0
				[2]			
				100			

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