OCR
Oxford Cambridge and RSA

GCE

Mathematics A

H240/02: Pure Mathematics and Statistics

Advanced GCE

Mark Scheme for November 2020

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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.

Question			Answer	Mark	AO	Guidance
1	(a)	(i)	$14(2x + 3)^6$ oe	M1 A1 [2]	1.1 1.1	M1 for $k(2x + 3)^6$ or $14u^6$ seen A1 all correct ISW
1	(a)	(ii)	$3x^2\ln x + x^2$ oe	M1 A1 A1 [3]	1.1 1.1 1.1	Attempt use product rule; allow incorrect sign; allow $\ln x\, 3x^2 + x^2$ One term correct All correct ISW eg factorised incorrectly
1	(b)		$\frac{1}{5}\sin 5x$ (+ c)	M1 A1 [2]	1.1 1.1	M1 for $\sin 5x$ seen NOT $-5\sin 5x$ A1 all correct. Allow without "+ c"
1	(c)		(y =) $3x^2 - 5x + 5$	M1 A1 [2]	1.1 1.1	M1 for attempt integrate $6x - 5$ A1 all correct, including y =
2			Numerator $\equiv (x + 1)(x - 2)(2x + 3)$ Denominator $\equiv (x + 1)(x - 2)$ Ans: $2x + 3$	M1 M1 M1 A1	3.1a 1.1 1.1 1.1	Attempt factorise numerator into 3 linear factors Attempt factorise denominator into 2 linear factors "cancel" two common factors in num & denom Allow no mention of $x \neq -1$ or $x \neq 2$ conditions. NB correct answer with no working or partial working: 4 marks
				[4]		SC: Answer $x + \frac{3}{2}$ B3
			Alternative method $2x+3$ $x^2-x-2 \overline{)2x^3+x^2-7x-6}$ $2x^3-2x^2-4x$ $3x^2-3x-6$ $3x^2-3x-6$ $-$ $2x + 3$	M1 A1 A1 A1		Attempt long division by $x^2 - x - 2$ or by $x + 1$ or by $x - 2$ Obtain "$2x$" in quotient Obtain "+ 3" in quotient Answer $2x + 3$ clear (not just in the division sum)

Question			Answer	Mark	AO	Guidance
3	(a)	(i)	$1 + (-2)(-x) + \frac{(-2)(-3)}{2!}(-x)^2 + \frac{(-2)(-3)(-4)}{3!}(-x)^3$	M1	1.1	Correct expressions for at least three terms. May be implied
			$\equiv 1 + 2x + 3x^2 + 4x^3$	A1 [2]	1.1	cao
3	(a)	(ii)	$(n + 1)\, x^n$	B1 [1]	2.2a	Allow $x^n = (n + 1)\, x^n$
3	(b)		$\frac{1}{1-x}$ oe	B1 [1]	1.1	
3	(c)		$2 + 3x + 4x^2 + 5x^3 + ...$ $= 1 + x + x^2 + x^3 + ...$ $+ 1 + 2x + 3x^2 + 4x^3 + ...$	M1	3.1a	
			$= \frac{1}{1-x} + \frac{1}{(1-x)^2} = \frac{(1-x)+1}{(1-x)^2}$	M1	3.1a	Their (b)(i) + $\frac{1}{(1-x)^2}$ and attempt single term
			$= \frac{2-x}{(1-x)^2}$	A1 [3]	1.1	cao Unsupported answer, no marks
			$(a - x)(1 - x)^{-2}$	M1		
			$a + 2ax + 3ax^2 + 4ax^3 + ...$ $-(x + 2x^2 + 3x^3 + 4x^4 + ...)$	M1		
			$a = 2$ $\frac{2-x}{(1-x)^2}$			
			Justification for all terms up to infinity	A1		
						NB other correct methods exist

Question			Answer	Mark	AO	Guidance
4			**DR** $3\sin^4\phi + \sin^2\phi - 4 = 0$			
			$(3\sin^2\phi + 4)(\sin^2\phi - 1) = 0$	**B1**	**2.1**	Attempt to solve QE in $\sin^2\phi$ or QE in u with $u = \sin^2\phi$ soi **Must see method**
			$\sin^2\phi = -\frac{4}{3}$ or $\sin^2\phi = 1$ (or $\sin\phi = 1$)	**B1**	**1.1**	May be implied from $x = \sin^2\phi$ and $x = -\frac{4}{3}$ or 1
			$\sin^2\phi = -\frac{4}{3}$ is impossible	**B1**	**2.3**	oe, eg $\sin\phi \neq \sqrt{-\frac{4}{3}}$ **Not** with incorrect reason, eg $\sin^2\phi = \frac{16}{9} > 1$
			$\phi = \sin^{-1}(\pm 1)$	**M1**	**1.1**	solve for ϕ Allow $\phi = \sin^{-1}(1)$, may be implied
			$\phi = \frac{1}{2}\pi, \frac{3}{2}\pi$ No extras within range Allow "correct" extras outside range	**A1**	**2.2a**	Both. dep $\sin^2\phi = -\frac{4}{3}$ and $\sin^2\phi = 1$ (or $\sin\phi = 1$) seen
				[5]		SC $\phi = \frac{1}{2}\pi, \frac{3}{2}\pi$ with no working: B2
5	**(a)**		$n^2 - 1$ or $n^2 + 1$ is even OR n^2 is odd or $n^2 = 2k + 1$ (k integer)			B1 for <u>any</u> of these. Numerical examples insufficient
			OR $\frac{n^2-1}{2} > 0$ or $\frac{n^2-1}{2} \geq 1$ oe eg $n^2 \geq 3$	**B1**	**2.4**	Ignore extra, eg $\frac{n^2+1}{2} > 0 \Rightarrow n^2 > -1$ or $n > \sqrt{-1}$ or $n \neq -1$ Allow ≥ 0 for this mark
			Assuming *n* is a positive integer:			**Not assuming *n* is a positive integer:**
			n is odd oe eg $n = 2k + 1$ (k integer)	**B1**	**2.2a**	
			$n > 1$ (or $n < -1$) or $\lvert n\rvert > 1$ or $n \geq \sqrt{3}$ Not $n \geq 0$ NOT $n > \pm 1$ but ignore this if followed by correct, eg $\lvert n\rvert > 1$	**B1**	**2.2a**	$n = \sqrt{\text{odd integers} > 1}$ or $n = \sqrt{3}, \sqrt{5}$ etc oe B2 indep 2nd and 3rd B1 marks are independent & can be gained without explanation
				[3]		
5	**(b)**		$n^2 + (\frac{n^2-1}{2})^2$	**M1**	**3.1a**	$(\frac{n^2+1}{2})^2 - (\frac{n^2-1}{2})^2$ correct expression
			$= n^2 + \frac{n^4-2n^2+1}{4} = \frac{n^4+2n^2+1}{4}$			$= \frac{n^4+2n^2+1}{4} - \frac{n^4-2n^2+1}{4} = \frac{4n^2}{4}$
			$= \left(\frac{n^2+1}{2}\right)^2$	**A1**	**1.1**	$= n^2$ Correctly obtained
				[2]		

Question			Answer	Mark	AO	Guidance
5	(b)	ctd	$n^2 + (\frac{n^2-1}{2})^2 = \left(\frac{n^2+1}{2}\right)^2$ $n^2 + \frac{n^4-2n^2+1}{4} = \frac{n^4+2n^2+1}{4}$ $\frac{4n^2+n^4-2n^2+1}{4} = \frac{n^4+2n^2+1}{4}$	M1 A1		
6			LHS $\equiv \sqrt{2}(\cos 2\theta \cos 45^o - \sin 2\theta \sin 45^o)$ $\equiv \sqrt{2} \times \frac{1}{\sqrt{2}}(\cos 2\theta - \sin 2\theta)$ or $(\cos 2\theta - \sin 2\theta)$ $\equiv \cos^2\theta - 2\sin\theta\cos\theta - \sin^2\theta$	M1 B1 A1	3.1a 1.1 2.2a	correct use of $\cos(A+B)$ formula $\cos 45^o$ or $\sin 45^o = \frac{1}{\sqrt{2}}$ seen or implied correctly obtained – use of double angle formulae clear
			Alternative method RHS $\equiv \cos 2\theta - \sin 2\theta$ $\equiv \sqrt{2}(\frac{1}{\sqrt{2}}\cos 2\theta - \frac{1}{\sqrt{2}}\sin 2\theta)$ $\equiv \sqrt{2}(\cos 2\theta \cos 45^o - \sin 2\theta \sin 45^o)$ $\equiv \sqrt{2}\cos(2\theta + 45^o)$	M1 M1 A1		or $R\cos\alpha = 1$, $R\sin\alpha = 1$, $R^2 = 2$, $\tan\alpha = 1$, $\alpha = 45^o$
				[3]		
7	all		Allow a and b without "squiggles" beneath			
7	(a)		Length of AB oe	B1 [1]	1.2	Magnitude of $\overrightarrow{AB}$ or distance from A to B Allow Magnitude of AB Not magnitude of $\lvert\mathbf{a}-\mathbf{b}\rvert$ or magnitude of $\mathbf{a}-\mathbf{b}$ Not distance from a to b Not distance from position vector A to position vector B
7	(b)		Midpoint of AB oe	B1 [1]	1.2	or Halfway between A and B Allow Midpoint of $\overrightarrow{AB}$ Must refer to A and B, not a and b Not Midpoint of the vectors
7	(c)	(i)	$\frac{1}{2}(\mathbf{a}+\mathbf{b})$	B1 [1]	2.2a	
7	(c)	(ii)	$\frac{1}{2}\lvert\mathbf{a}-\mathbf{b}\rvert$ oe	B1 [1]	2.2a	

Question			Answer	Mark	AO	Guidance
7	(d)		Centre is (3, 2)	B1	1.1	Allow this mark for (3, 2) or $\begin{pmatrix}3\\2\end{pmatrix}$ or $\frac{1}{2}\begin{pmatrix}6\\4\end{pmatrix}$ oe seen May be implied by answer
			$r^2 = 10$ or $r = \sqrt{10}$ or 3.16 (3 sf)	B1	1.1	May be implied by answer. Must imply radius
				M1	1.1	M1 for $(x-a)^2+(y-b)^2 = r^2$ for any non-zero numerical a, b and r
			$(x-3)^2 + (y-2)^2 = 10$	A1	1.1	A1 for all correct. **ISW**
				[4]		
8	(a)		Summary scheme			
			Attempt separate variables using $(100 - P)$	M1	3.1a	
			Correct integral, but allowing $\lvert 100 - P\rvert$ or $(P - 100)$ or $(100 - P)$	A1	1.1	Allow without + c
			Attempt $t = 0$, $P = 2000$ to find c or A or $e^{\pm c}$	M1	3.4	dep M1
			$c = -\ln 1900$ or $A = 1900$ or $e^{\pm c} = 1900$ OR Allow $c = \ln 1900$ or $-\ln(-1900)$ or A or $e^{\pm c} = -1900$ or $-\frac{1}{1900}$	A1	3.4	dep M1M1
			Attempt make P the subject	M1	3.4	dep M1M1A1
			Correct use of mod & change to $P - 100$	M1	2.1	
			$P = 1900e^{-t} + 100$	A1	1.1	dep M1A1M1A1M1M1 ie dep all correct working seen
			Examples of correct methods			
			$\frac{dP}{100-P} = dt$	M1		
			$-\ln\lvert 100 - P\rvert = t + c$ or $\lvert 100 - P\rvert = Ae^{-t}$	A1		
			Substitute $t = 0$, $P = 2000$	M1		
			$\Rightarrow c = -\ln 1900$ or $A = 1900$	A1		
			$\ln\frac{\lvert 100-P\rvert}{1900} = -t$ or $\lvert 100 - P\rvert = 1900e^{-t}$			
			$\frac{P-100}{1900} = e^{-t}$			
				M1		
			$P = 1900e^{-t} + 100$	A1		
				A1		

Question			Answer	Mark	AO	Guidance
8	(a)	ctd	$\frac{dP}{P-100} = -dt$	M1		
				M1		
			$\ln(P-100) = -t + c$ or $P - 100 = Ae^{-t}$	A1		
			Substitute $t = 0$, $P = 2000$	M1		
			$\Rightarrow c = \ln 1900$ correct or $A = 1900$	A1		
			$\ln(P-100) = -t + \ln 1900$ or $P - 100 = 1900e^{-t}$			
			$\frac{P-100}{1900} = e^{-t}$			
			$P = 1900e^{-t} + 100$	M1		
				A1		
			Example of incorrect methods			(
			$\frac{dP}{100-P} = dt$	M1		
			$-\ln(100-P) = t + c$ or $100 - P = Ae^{-t}$	A1		
			$100 - P = e^{-t-c}$			
			Substitute $t = 0$, $P = 2000$	M1		
			$\Rightarrow e^{-c} = -1900$ or $A = -1900$	A1		
			$100 - P = -1900e^{-t}$ oe			
			No change to $P - 100$	M0		
			$P = 1900e^{-t} + 100$	M1		
				A0		Correct answer but incorrectly obtained, not using modulus
			$\frac{dP}{100-P} = dt$	M1		
			$\ln(100-P) = t + c$	A0		
			Substitute $t = 0$, $P = 2000$	M1		
			$\ln(-1900) = c$	A1		
			$\ln(100-P) = t + \ln(-1900)$			
			$100 - P = -1900e^{t}$			
			No change to $P - 100$	M0		
			$P = 100 + 1900e^{t}$	M1		
				A0		

Question			Answer	Mark	AO	Guidance
8	(b)		(Starts at 2000) Decreases Approaches 100	B1f B1f [2]	3.4 3.4	B1 for correct process or ft (a) dep (a) includes exponential B1 for correct limit or ft (a) dep (a) includes exponential
9	(a)		(40000 × 0.002 =) 80	B1 [1]	1.1	
9	(b)		Frequency per £ or No. of cars per £	B1 [1]	1.1	Allow cars / £ Allow as fraction NOT cars / price NOT cars / money
9	(c)		Show fds for four separate classes within £50000 - £90000	B1 [1]	2.3	Make price intervals smaller Show the median (or similar) Include more bars Give a title Explain *y*-axis better or give units of f.d. Give the frequencies
9	(d)		20	B1f [1]	1.1	or (a) ÷ 4

Question	Answer	Mark	AO	Guidance
10	H_0: $p = 0.9$, where p = P(a random customer is satisfied)	B1	1.1	**Allow rounded or truncated to 2 sf throughout** or p is proportion satisfied Allow other letters OR p = 90%, where p is % of customers satisfied
	H_1: $p < 0.9$	B1	2.5	Subtract B1 for each error eg: 2-tail B1B0 Use of $\leq$ with definition B1B0 undefined p B1B0 Not include value 0.9 B0B0 not in terms of parameter B1B0 $H_0 = 0.9$ etc: B0B0
	X~Bin(15, 0.9) and $X \leq 10$ or 11 or 12 (condone < or = or > or $\geq$)	M1	3.3	Stated or implied eg by 0.0556 or 0.184 or 0.0127 or 0.944 or 0.816 or 0.987 or 0.0428 or 0.129
	P($X \leq 11$) oe = 0.0556 | P($X > 11$) oe = 0.944	A1	3.4	**BC** cao
	Comp 0.05 | Comp 0.95	A1	1.1	Dep 0.0556 or 0.184 or 0.0127 or 0.944 or 0.816 or 0.987 Must be correct comparison, eg not 0.944 comp with 0.05
	Alternative method for middle two A-marks P($X \leq 10$) = 0.0127 P($X \leq 11$) = 0.0556	A1		Both needed
	Hence rejection region is $X \leq 10$ (or $X < 11$) or critical value is $X = 10$	A1		Dep on M1
	Do not reject H_0 Condone Accept H_0	M1	1.1	Dep 0.0556 or 0.184 or 0.0127 **(2 sf)** or P($X \leq 10$ or 11 or 12)seen or 0.944 or 0.816 or 0.987 P($X > 10$ or 11 or 12) seen And dep correct comparison, eg, not 0.944 comp with 0.05
	There is insufficient evidence that Pierre is overconfident (or that < 90% are satisfied) oe, eg There is insufficient evidence that Yvette's suspicion is correct	A1f	2.2b	In context. Not definite. Full statement Not: There is evidence that Pierre is not overconfident oe
		[7]		
	N~Bin: $\mu = 13.5$, $\mu < 13.5$ B1B0 N(13.5, 1.35) & X =11.5 or 11 M1 p = 0.0426 A1 compare 0.05 A1 Conclusion M0A0			dep defined μ. If undefined: B0B0 soi dep 0.0426 or 0.0157

Question			Answer	Mark	AO	Guidance
10	**ctd**		2-tail: H_0: $p = 0.9$ defined p H_1: $p \neq 0.9$ X~Bin(15, 0.9) and $X \leq 11$ or 12 (condone < or = or > or ≥) P($X \leq 11$) oe = 0.0556 Comp 0.025 Conclusion	 **B1** **B0** **M1** **A1** **A1** **M0** **A0**		 Stated or implied eg by 0.0556 or 0.184 or 0.944 or 0.816 or 0.0428 or 0.129 Dep 0.0556 or 0.184
11	**(a)**		(mean =) 201 (3 sf) (sd =) 60.7 (3 sf)	**B1** **B1** **[2]**	**1.1** **1.1**	 Allow 60.8
11	**(b)**		0.364 (3 sf)	**B1** **[1]**	**3.4**	
11	**(c)**		P($X < 160$) = 0.252(49) $x_1 = \Phi^{-1}(0.6 + '0.25249')$ = 262.83 (5 sf) ISW	**B1** **M1** **A1** **[3]**	**3.4** **1.1** **1.1**	soi, eg by P($X > 160$) = 0.748 or 0.747 or by 0.147 or 0.148 T&I: correct answer scores B1M1A1, otherwise max B1 SC Answer 263 with correct working: B1M1A0 SC Answer 263 with inadequate working: B1 only
11	**(d)**		112 and 288 are within 2 sd from mean (no working needed) P($X < 112$) = 0.0708, which is > 0.025 or > 0.0013 or > 0	 **B1** **[1]**	 **3.5a**	or $\mu + 2\sigma = 320$ ($\mu + 3\sigma = 380$) which is > than 288 or P(112< M < 288) = 0.858 which is < than 0.95 (or 0.99) or p = 0.858, but model suggests $p = 1$ NOT 0.858 alone B0
11	**(e)**		Reduce σ $288 - 200 = 2\sigma$ or $288 - 200 = 3\sigma$ or $288 - 112 = 4\sigma$ or $288 - 112 = 6\sigma$ $\sigma = 44$ $\sigma = 29.3$ or about 30	**B1** **B1** **[2]**	**3.5c** **3.3**	May be implied by value of σ Allow more precise correct methods Allow σ between 25 and 50. No working needed B1B1 or σ^2 between 625 and 2500

Question			Answer	Mark	AO	Guidance
12	(a)		H_0: $\mu = 45.7$, where μ = mean of all new journey times H_1: $\mu < 45.7$	B1 B1 [2]	1.1 2.5	Allow "where μ = mean journey time" Allow different letters Subtract B1 for each error eg: use of "p" unless defined B0B0 2-tail B1B0 μ= sample mean implied B1B0 undefined μ B1B0 Not include value 45.7 B0B0 not in terms of parameter B1B0 $H_0 = 45.7$ etc: B0B0
12	(b)		N(45.7, $\frac{5.6^2}{30}$) and probability = 0.025 soi P($\bar{X} < a$) = 0.025 or $a = \Phi^{-1}(0.025)$ a = 43.7 (3 sf) (43.696....) Rejection region is ($\bar{X}$) < 43.7 (3 sf) or ($\bar{X}$) < 43.6 with explanation	M1* M1 A1f A1 [4]	3.3 1.1 1.1 1.1	or N(45.7, $\frac{392}{375}$) or N(45.7, 1.045) and probability = 0.025 soi soi Dep M1 Allow $\leq$. Answer ($\bar{X}$) < 34.7 SC B1 (from not ÷ by $\sqrt{30}$) Correct answer with inadequate or no working: SC B2 If (a) $\mu > 45.7$, allow ($\bar{X}$) > 47.7, M1M1A1A0
13	(a)	(i)	P(AA or BAA) = $0.4^2 + 0.6\times0.4^2$ oe = 0.256 or $\frac{32}{125}$	M1 A1 [2]	3.1b 1.1	allow M1 for either 0.4^2 (×...) or 0.6×0.4^2 (×...)
13	(a)	(ii)	ABA or BAB P(ABA or BAB) = $0.4^2 \times 0.6 + 0.6^2 \times 0.4$ 0.24	M1 M1 A1	3.1b 1.1 1.1	both seen or implied M1 for either $0.4^2\times0.6$ or $0.6^2 \times0.4$
			Alternative method 1 – ("0.256" + 0.6^2 + 0.4×0.6^2) = 0.24	 M1 M1 A1 [3]		 M1 for 1 – P(A wins or B wins) attempted M1 for 1 – ("0.256" (+ .....)) or 1 – ((.....)+ 0.6^2 + 0.4×0.6^2) NB 0.4 × 0.6 = 0.24: M0M0A0
13	(b)		'0.256' + '0.24'×'0.256' + '0.24^2'×0.256 +.... = $\frac{0.256}{1-0.24}$ = $\frac{32}{95}$ or 0.337 (3 sf)	M1 M1 A1 [3]	3.1b 2.1 1.1	ft (a)(i)&(ii) ft (a)(i)&(ii) ie $\frac{(a)(i)}{1-(a)(ii)}$ cao S_5 = 0.337 SC B1, but with added comment M1M1A1

Question			Answer	Mark	AO	Guidance
14	(a)	(i)	The actual number of extra pupils determines the number of places needed Shows how many new students there will be Shows trend so LA can provide accordingly Need to know expected number of pupils	B1 [1]	2.2b	The existing numbers are already catered for Increase in provision Not Need to know increase in proportion of pupils
14	(a)	(ii)	Wigan Increase in number is greatest there	B1 B1 [2]	2.2b 2.2b	Allow "Wigan and Bolton" Ignore mention of % increase. Ignore extras.
14	(a)	(iii)	E.g. all those in this category stay in the LA Populations continue growing at same rate Populations all growing at same rate The population increases consistently NOT Increase has been steady All LAs have the same teacher/pupil ratio All LAs have same need for teachers in 2011	B1 [1]	2.2b	No decrease in population Children born in that LA will go to school in that LA Assume no great influx or outflow of children after 2011. The LAs are not currently understaffed Ignore extra eg "between 2001 & 2011"
14	(b)		Manchester and Salford B1 Highest % or absolute increase B1dep Manchester and Liverpool B1 The two highest in 2011 B1dep SC Manchester (alone), Highest % or absolute increase: B1B0	B1 B1 [2]	2.2b 2.4	Wigan and Bolton B1 Highest numbers in 2011 except Manchester and Liverpool, which are very large B1dep Salford and Trafford B1 They have the largest absolute (or %) increase, but are small (or not huge like Manchester) B1dep
15	(a)		**DR** $\frac{15}{64}\times\frac{2^2}{2!}$ oe eg $\frac{15}{64}\times\frac{4}{2}$ ($=\frac{15}{32}$ **AG**)	B1 [1]	1.1	Must see this expression and result

Question			Answer	Mark	AO	Guidance
15	(b)		**DR** 2, 2, 5 2, 3, 4 3, 3, 3	**M1**	**3.1a**	Any two seen, with no more than 2 extra different combinations. eg 0, 4, 5 and 0, 5, 4 count as <u>one</u> extra
			$P(X_1 + X_2 + X_3 = 9) =$			
			$3\times(\frac{15}{32})^2\times\frac{5}{80}+6\times\frac{15}{32}\times\frac{5}{16}\times\frac{5}{32}+(\frac{5}{16})^3$			M2: <u>≥</u> 1 correct product actually seen & all three products correct
			0.0412 + 0.1373 + 0.0305	**M1**	**2.1**	M1: 1 correct product seen
			$3\times\frac{225}{16384}+6\times\frac{375}{16384}+\frac{125}{4096}$	**M1**	**2.1**	or all correct except omission of, or incorrect, multiple(s) or all three results or total correct, but without working
			$\frac{675}{16384}+\frac{1125}{8192}+\frac{125}{4096}$ (= 0.209045)			
			$P(X_1 + X_2 + X_3 = 9$ and at least 1 X value $= 2)$			
			$=3\times(\frac{15}{32})^2\times\frac{5}{80}+6\times\frac{15}{32}\times\frac{5}{16}\times\frac{5}{32}$ (= 0.178528)	**M1**	**1.1**	Allow M1 for 1 correct product or omit, or incorrect, multiple(s) or ft their probabilities from their previous calculation
			$\frac{'0.178528'}{'0.209045'}$	**M1**	**2.1**	÷ their attempted probs of correct events
			= 0.854 (3 sf) or $\frac{117}{137}$	**A1**	**2.2a**	
			$P(X_1 + X_2 + X_3 = 9$ and no X value $= 2)$			
			$=(\frac{5}{16})^3$ (= 0.030518 or $\frac{125}{4096}$)	**M1**		ft their P(3, 3, 3)
			$1-\frac{'0.030518'}{'0.209045'}$	**M1**		÷ their attempted probabilities of correct events & subtract from 1
			= 0.854 (3 sf) or $\frac{117}{137}$	**A1**		NB $1-(\frac{5}{16})^3$ alone scores M1
				[6]		

Question			Answer	Mark	AO	Guidance
15	(c)		P(two 2's in nine vales of X) or 0.094466 or ${}^9C_2 \times (1-\frac{15}{32})^7 \times (\frac{15}{32})^2$	M1	3.1a	soi eg by ${}^9C_2$ seen
			P(two 2's in nine vales of X) × P(X = 2) or 0.094466 × $\frac{15}{32}$ or ${}^9C_2 \times (1-\frac{15}{32})^7 \times (\frac{15}{32})^3$	M1	2.1	soi NB $\left(\frac{17}{32}\right)^7 \times \left(\frac{15}{32}\right)^3$ scores 0, unless multiplied by ${}^9C_2$
			0.0443 (3 sf)	A1 [3]	1.1	

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