



## Mark Scheme (Results)

October 2018

Pearson Edexcel International Advanced Level  
in Statistics S2 (WST02/01)

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## General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

## PEARSON EDEXCEL IAL MATHEMATICS

### General Instructions for Marking

1. The total number of marks for the paper is 75
2. The Edexcel Mathematics mark schemes use the following types of marks:
  - **M** marks: Method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
  - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
  - **B** marks are unconditional accuracy marks (independent of M marks)
  - Marks should not be subdivided.
3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.


- bod – benefit of doubt
- ft – follow through
- the symbol  $\checkmark$  will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- d... or dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- \* The answer is printed on the paper or ag- answer given
- $\square$  or d... The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.
6. If a candidate makes more than one attempt at any question:
  - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
  - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer.

October 2018  
WST02 STATISTICS 2  
Mark Scheme

Question	Scheme	Marks
<b>1.(a)</b>	$X \sim \text{Po}(6)$ $P(X = 1) [=6e^{-6} = 0.0174 - 0.0025] = 0.01487\dots$	M1 A1 (2)
<b>(b)</b>	$H_0 : \lambda = 6$ (or 9) $H_1 : \lambda > 6$ (or 9) $Y \sim \text{Po}(9)$ $P(Y \geq 14) = 1 - P(Y \leq 13) = 1 - 0.9261 = 0.0739 / P(Y \geq 15) = 0.0415$ , CR: $Y \geq 15$ Do not reject $H_0$ /Not significant/ 14 is not in the critical region There is not enough evidence to suggest that the rate of <b>calls</b> for reservations has increased.	B1 M1A1 dM1 A1cso (5) <b>Total 7</b>
<b>Notes</b>		
<b>(a)</b>	1 <sup>st</sup> M1 writing or using Po(6)	
<b>(b)</b>	1 <sup>st</sup> B1 for both hypotheses correct with $\lambda$ or $\mu$  1 <sup>st</sup> M1 for writing or using $1 - P(Y \leq 13)$ and Po(9) <u>or</u> writing or using $P(Y \geq 15)$ and Po(9) for a CR method 1 <sup>st</sup> A1 for awrt 0.0739 / CR: $Y \geq 15 / Y > 14$  2 <sup>nd</sup> dM1 dependent on 1 <sup>st</sup> M1 for correct statement (i.e. Do not reject $H_0$ /Not significant/14 is not in the critical region) (may be implied by a correct contextual statement). Do not allow contradictory statements. 2 <sup>nd</sup> A1cso A correct contextual statement must include the word <b>calls</b> and the idea the rate has not increased. All previous marks must be awarded for this mark to be awarded.  <b>SC:</b> $1 - P(Y \leq 14) = 0.0415$ so reject $H_0$ scores M0A0M1A0	

Question	Scheme	Marks
<b>2.(a)</b>	$X \sim B(12, 0.2)$ $P(X < 3) = P(X \leq 2) = 0.5583\dots$	B1 M1A1 (3) awrt <b>0.558</b>
<b>(b)(i)</b>	$[P(\text{customer takes sugar}) =] 0.8 \times 0.35 + 0.2 \times 0.6 [= 0.4*]$	B1cso (1)
<b>(ii)</b>	$[Y \sim] B(n, 0.4)$	B1 (1)
<b>(c)(i)</b>	$P(Y = 4) [= {}^{10}C_4(0.4^4)(0.6^6) = 0.6331 - 0.3823] = 0.2508$	B1 (1) awrt <b>0.251</b>
<b>(ii)</b>	$P(Y \leq 6 / Y \geq 3) = \frac{P(3 \leq Y \leq 6)}{P(Y \geq 3)}$ $\frac{P(Y \leq 6) - P(Y \leq 2)}{1 - P(Y \leq 2)} = \frac{0.9452 - 0.1673 [= 0.7779]}{1 - 0.1673 [= 0.8327]} = 0.934\dots$	M1 M1A1 (3) awrt <b>0.934</b>
<b>(d)</b>	$C \sim B(150, 0.4) \rightarrow N(60, 36)$ $P(C \geq 75) = P\left(Z > \frac{74.5 - 60}{\sqrt{36}}\right) [= P(Z > 2.416\dots)]$ $1 - 0.9922 = 0.0078$	M1 M1 M1 A1 (4) awrt <b>0.0078</b>
<b>Total 13</b>		
<b>Notes</b>		
<b>(a)</b>	B1 for writing or using $B(10, 0.2)$ M1 for writing or using $P(X \leq 2)$	
<b>(b)(i)</b>	B1cso for $0.8 \times 0.35 + 0.2 \times 0.6$ or equivalent Condone use of percentages here	
<b>(ii)</b>	B1 $B(n, 0.4)$	
<b>(c)(ii)</b>	1 <sup>st</sup> M1 for a correct ratio expression [Do not allow $P(Y \leq 6 \cap Y \geq 3)$ on numerator] 2 <sup>nd</sup> M1 for writing or using $\frac{P(Y \leq 6) - P(Y \leq 2)}{1 - P(Y \leq 2)}$	
<b>(d)</b>	1 <sup>st</sup> M1 for using a Normal approximation to binomial with $\mu = np$ and $\sigma^2 = np(1 - p)$ 2 <sup>nd</sup> M1 for standardising 74.5, 75, 75.5 with their mean and standard deviation 3 <sup>rd</sup> M1 for use of continuity correction ( $75 \pm 0.5$ )  [Note actual probability is 0.00827...]	

Question	Scheme	Marks
<p><b>3.(a)</b></p> 	<p>This is not a valid probability density function since <math>f(x) &lt; 0</math> for <math>x &gt; 3</math></p> <p><b>(b)</b> <math>[g(y) = k(12y - y^3)]</math>  <math>[g'(y)] = k(12 - 3y^2)</math>  <math>12 - 3y^2 = 0</math>  <math>y = 2</math></p> <p><b>(c)</b> <math>\int k(12y - y^3)dy = k\left[6y^2 - \frac{y^4}{4}\right]_1^3</math>  <math>k\left(6 \times 3^2 - \frac{3^4}{4} - 6 + \frac{1}{4}\right) = 1</math>  <math>k = \frac{1}{28}</math></p> <p><b>(d)</b> <math>\int_1^m \frac{1}{28}(12y - y^3)dy = \frac{1}{28}\left(6 \times m^2 - \frac{m^4}{4} - \left(6 \times 1^2 - \frac{1^4}{4}\right)\right) = 0.5</math>  <math>m^4 - 24m^2 + 79 = 0 \rightarrow m = 1.98437\dots</math> awrt <b>1.98</b></p> <p><b>(e)</b> Median <math>\approx</math> Mode, therefore there is no skew.</p>	<p>B1 (shape) B1 (domain)</p> <p>B1 (3)</p> <p>M1 M1 A1 (3)</p> <p>M1 M1 A1 (3)</p> <p>M1 M1 A1 (3)</p> <p>M1 A1ft (2)</p> <p><b>Total 14</b></p>
<b>Notes</b>		
	<p><b>(a)</b> 1<sup>st</sup> B1 for correct shape (decreasing quadratic) for this mark ignore graph <math>x &lt; 1</math> and <math>x &gt; 4</math> must cross <math>x</math> axis  2<sup>nd</sup> B1 for correct domain (graph starting at <math>x = 1</math> and finishing at <math>x = 4</math>)  If <math>x = 3</math> is labelled, then it must be correctly placed at the <math>x</math>-intercept  3<sup>rd</sup> B1 for Not a density function/Albert is incorrect <b>and</b> correct supporting reason  Allow any reference to pdf cannot be negative.</p> <p><b>(b)</b> 1<sup>st</sup> M1 for expanding and attempting to differentiate (or using product rule to differentiate)  2<sup>nd</sup> M1 for equating to 0 and attempt to solve  A1 for 2 only</p> <p><b>(c)</b> 1<sup>st</sup> M1 for attempt to integrate (<math>y^n \rightarrow y^{n+1}</math>)  2<sup>nd</sup> M1 for equating to 1 and use of correct limits</p> <p><b>(d)</b> 1<sup>st</sup> M1 for use of <math>\int_1^m g(y)dy = 0.5</math>  2<sup>nd</sup> M1 for arranging to a 3TQ = 0 and attempt to solve  A1 awrt 1.98 only</p> <p><b>(e)</b> M1 for a comparison of <math>1 \leq</math> 'their (b)' <math>\leq 3</math> with <math>1 &lt;</math> 'their (d)' <math>\leq 3</math> Note: mean = 1.9857...  A1ft for no skew (allow [slight] negative skew). Correct statement following from their comparison  Note: mean = 1.9857... comparisons based on the mean must use correct mean awrt 1.99</p>	



Question	Scheme	Marks															
Question	Scheme	Marks															
4.(a)	$P(D = -1) [=P(1 \text{ blue and } 2 \text{ red marbles selected})] = 3 \times 0.2 \times 0.8^2 = 0.384^*$	M1A1cso (2)															
(b)	<table border="1"> <tr> <td><math>d</math></td> <td>-3</td> <td>[-1]</td> <td>1</td> <td>3</td> </tr> <tr> <td></td> <td><math>0.8^3</math></td> <td><math>[3 \times 0.2 \times 0.8^2]</math></td> <td><math>3 \times 0.2^2 \times 0.8</math></td> <td><math>0.2^3</math></td> </tr> <tr> <td><math>P(D = d)</math></td> <td><math>0.512 = \frac{64}{125}</math></td> <td><math>[0.384 = \frac{48}{125}]</math></td> <td><math>0.096 = \frac{12}{125}</math></td> <td><math>0.008 = \frac{1}{125}</math></td> </tr> </table>	$d$	-3	[-1]	1	3		$0.8^3$	$[3 \times 0.2 \times 0.8^2]$	$3 \times 0.2^2 \times 0.8$	$0.2^3$	$P(D = d)$	$0.512 = \frac{64}{125}$	$[0.384 = \frac{48}{125}]$	$0.096 = \frac{12}{125}$	$0.008 = \frac{1}{125}$	B1 M1 A1 (3)
$d$	-3	[-1]	1	3													
	$0.8^3$	$[3 \times 0.2 \times 0.8^2]$	$3 \times 0.2^2 \times 0.8$	$0.2^3$													
$P(D = d)$	$0.512 = \frac{64}{125}$	$[0.384 = \frac{48}{125}]$	$0.096 = \frac{12}{125}$	$0.008 = \frac{1}{125}$													
(c)	-3	B1 (1)															
(d)	$X \sim B(12, 0.2)$  $P(X \leq 4) = 0.9274$ $P(X \geq 5) = 0.0726 < 0.10$ $P(X \leq 3) = 0.7946$ $P(X \geq 4) = 0.2054 > 0.10$ CR: $X \geq 5$	M1  A1 (2)															
(e)	0.0726	B1ft (1)															
<b>Notes</b>		<b>Total 9</b>															
(a)	M1 for identifying 1 blue and 2 red leading to $0.2 \times (1 - 0.2)^2$ A1cso for a complete correct calculation $3 \times 0.2 \times 0.8^2$																
(b)	B1 for all correct $d$ -values M1 for correct expression for at least 1 other probability A1 for a complete distribution																
(d)	1 <sup>st</sup> M1 for using $X \sim B(12, 0.2)$ to find a relevant probability to determine a critical region [ $P(X \leq 3) = 0.7946$ , $P(X \geq 4) = 0.2054$ , $P(X \leq 4) = 0.9274$ , $P(X \geq 5) = 0.0726$ ]  $P(X \geq 5)$ as final answer is M1A0																
(e)	B1ft for a significance level consistent with their CR from (d). Must come from a one-tailed test from $X \sim B(12, 0.2)$ so may see $P(X \geq 6) = 0.0194$ or $P(X \geq 7) = 0.0039$																

Question	Scheme	Marks
<p><b>5.(a)</b></p> <p><b>(b)</b></p> <p><b>(c)</b></p>	$f(x) = \frac{1}{100}(3ax^2 + 2bx + 15)$ $E(X^2) = \int x^2 f(x)dx$ $\frac{1}{100} \left[ \frac{3}{5}ax^5 + \frac{1}{2}bx^4 + 5x^3 \right]_0^5 = 6.25$ $1875a + 312.5b + 625 = 625$ $6a + b = 0 *$ $F(5) = 1$ $\frac{1}{100}(125a + 25b + 75) = 1$ <p>Solving simultaneously <math>\begin{cases} 5a + b = 1 \\ 6a + b = 0 \end{cases}</math></p> $a = -1 \text{ and } b = 6$ $[P(3 \leq X \leq 7) =] F(5) - F(3) \text{ or } 1 - F(3)$ $1 - \frac{1}{100}(27a + 9b + 45)$ <p style="text-align: right;"><b><u>0.28</u></b></p>	<p>M1 A1</p> <p>M1 dM1 A1cso (5)</p> <p>M1</p> <p>M1</p> <p>A1 A1 (4)</p> <p>M1</p> <p>A1 (2)</p> <p><b>Total 11</b></p>
<b>Notes</b>		
<p><b>(a)</b></p> <p><b>(b)</b></p> <p><b>(c)</b></p>	<p><b>Mark parts (a) and (b) together as may see use of F(5) = 1 in part (a)</b></p> <p>1<sup>st</sup> M1 for use of <math>\frac{d}{dx}[F(x)]</math> to find <math>f(x)</math> (<math>x^n \rightarrow x^{n-1}</math>)</p> <p>1<sup>st</sup> A1 for correct differentiation</p> <p>2<sup>nd</sup> M1 for attempt to integrate <math>\int x^2 f(x)dx</math> (ignore limits) (<math>x^n \rightarrow x^{n+1}</math>)</p> <p>Should see <math>x^5</math> as the highest power of <math>x</math> here</p> <p>3<sup>rd</sup> dM1 for <math>\int x^2 f(x)dx = 6.25</math> <b>and</b> substitution of <math>x = 5</math> to obtain an equation in terms of <math>a</math> and <math>b</math> only (dependent upon 2<sup>nd</sup> M1)</p> <p>2<sup>nd</sup> A1cso for <math>6a + b = 0</math> from correct working</p> <p>1<sup>st</sup> M1 for use of <math>F(5) = 1</math></p> <p>2<sup>nd</sup> M1 for solving simultaneously leading to <math>a = \dots</math></p> <p>1<sup>st</sup> A1 for <math>a = -1</math></p> <p>2<sup>nd</sup> A1 for <math>b = 6</math></p> <p>M1 for <math>1 - F(3)</math> or <math>\int_3^5 f(x)dx</math> attempt to integrate with use of correct limits</p> <p>A1 0.28oe</p>	

Question	Scheme	Marks
<b>6.(a)</b>	$a = 4 \times (-0.5)$ and $b = 4 \times 0.5$	B1 (1)
<b>(b)(i)</b>	$\sqrt{\frac{(2 - (-2))^2}{12}} = \frac{2\sqrt{3}}{3} = 1.1547\dots$	awrt <b>1.15</b> M1 A1
<b>(ii)</b>	$[P(-\frac{2\sqrt{3}}{3} < W < \frac{2\sqrt{3}}{3}) = ] \frac{\frac{2\sqrt{3}}{3} - (-\frac{2\sqrt{3}}{3})}{2 - (-2)} = \frac{\sqrt{3}}{3} = 0.57735\dots$	awrt <b>0.577</b> M1 A1 (4)
<b>(c)</b>	$P(W > 1.9) = \frac{2-1.9}{2-(-2)} [=0.025]$ $X \sim B(100, 0.025)$ $\rightarrow \text{Po}(2.5) \quad P(X \geq 5) = 1 - P(X \leq 4) = 1 - 0.8912 = 0.1088$	awrt <b>0.109</b> M1 M1 M1 A1 (4)
<b>Notes</b>		<b>Total 9</b>
<b>(a)</b>	B1 for correct explanation that each error is $[-0.5, 0.5]$ and these are multiplied by 4. It must be clear that $W$ could be above or below the true value.	
<b>(b)(i)</b>	M1 for use of correct formula with square root A1 awrt 1.15 (allow 1.155)	
<b>(ii)</b>	M1 for a correct follow through ( $2 \times \frac{1}{4} \times$ their (b)(i) )	
<b>(c)</b>	1 <sup>st</sup> M1 for a correct expression for $P(W > 1.9)$ 2 <sup>nd</sup> M1 for Binomial distribution $B(100, P(W > 1.9))$ 3 <sup>rd</sup> M1 for Poisson approximation with mean $100 \times P(W > 1.9)$ <b>and</b> $1 - P(X \leq 4)$  Note: using binomial distribution gives 0.106...	

Question	Scheme	Marks
7.(a)	$X \sim \text{Po}(1)$ and $P(X \geq n) < 0.05$ or $P(X < n) > 0.95$ $n = 4$	M1 A1 (2)
(b)	$Y \sim \text{Po}(0.5m)$ $P(Y = 0) < 0.05$ or $e^{-\frac{1}{2}m} < 0.05$ $0.5m = 3$ $m = 6$	M1 A1 (2)
(c)	$W \sim \text{Po}(0.5)$ $[P(W \geq 1)]^3 = (1 - P(W = 0))^3 = (1 - 0.6065)^3 = 0.06093\dots$	awrt <b>0.0609</b> M1M1A1 (3)
(d)	$S \sim \text{Po}(4)$ $P(S = 4) = 0.1953\dots$	awrt <b>0.195</b> M1 A1 (2)
(e)	$A \sim \text{Po}(1)$ $B \sim \text{Po}(2)$ $P(\text{sightings in last 2 months} > \text{sightings in first 2 months} \mid 4 \text{ sightings in 4 months}) =$ $\frac{P(A = 1) \times P(A = 3) + P(A = 0) \times P(A = 4)}{P(B = 4)} = \frac{e^{-1} \times \frac{e^{-1}}{3!} + e^{-1} \times \frac{e^{-1}}{4!}}{\frac{e^{-2} \times 2^4}{4!}} = \frac{5}{16}$	M1 M1 A1 (3) <b>Total 12</b>
<b>Notes</b>		
(a)	M1 for writing or using $\text{Po}(1)$ and $P(X \geq n) < 0.05$ or $P(X < n) > 0.95$ or for $\text{Po}(1)$ and $P(X \leq 2) = 0.9197$ or $P(X \leq 3) = 0.9810$ or $P(X > 2) = 0.0803$ or $P(X > 3) = 0.019$	
(b)	M1 for $P(Y = 0) = 0.1353$ from $\text{Po}(2)$ or $P(Y = 0) = 0.0821$ from $\text{Po}(2.5)$ or $P(Y = 0) = 0.0498$ from $\text{Po}(3)$	
(c)	1 <sup>st</sup> M1 for $P(W \geq 1)$ and $\text{Po}(0.5)$ 2 <sup>nd</sup> M1 for $(1 - P(W = 0))^3$ (allow $W \sim \text{Po}(\lambda)$ $\lambda > 0$ )	
(d)	M1 for use of $\text{Po}(4)$	
(e)	1 <sup>st</sup> M1 for $P(A = 1) \times P(A = 3) [= 0.02255\dots] + P(A = 0) \times P(A = 4) [= 0.0056\dots]$ from $\text{Po}(1)$ 2 <sup>nd</sup> M1 for conditional probability with $P(B = 4) [= 0.0902\dots]$ on the denom from $\text{Po}(2)$ (M0 if num > denom) A1 allow awrt 0.312/0.313	

