



Mark Scheme (Results)

Summer 2016

Pearson Edexcel International A Level
Statistics 2

(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.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

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)
 - dep – dependent
 - indep – independent
 - dp decimal places
 - sf significant figures
 - * The answer is printed on the paper
 - \square 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.

WST02 June 2016

Question Number	Scheme	Marks
1. (a)	$(X \sim \text{Po}(9), P(X \leq 10) = 0.7060)$ $v = 11$ [Not $v > 11$ or any inequality]	B1 (1)
(b)	$P(4 \leq X \leq 11) = P(X \leq 11) - P(X \leq 3)$ $0.8030 - 0.0212 = 0.7818$	M1 A1 (2) awrt 0.782
(c)	$\text{Po}(1.5)$ $P(Y > 1) = 1 - P(Y \leq 1)$ or $1 - 0.5578$ $= 0.4422$	B1 M1 A1 (3) awrt 0.442
(d)	[Let W = number of visits to the school website in 8 hours.] $W \sim \text{Po}(72)$ approximately $N(72, 72)$ $P(W > 80) = P\left(Z > \frac{80.5 - 72}{\sqrt{72}}\right)$ $= P(Z > 1.00\dots)$ $= 0.1587$ (or 0.15824 from calculator)	M1 A1 M1 M1 A1 (5) [11]
Notes		
(b)	M1 for writing or using $P(X \leq 11) - P(X \leq 3)$ May be implied by a correct answer.	
(c)	B1 for writing or using $\text{Po}(1.5)$ May be implied by $P(X = 0) = 0.2231$ or $P(X = 1) = 0.3346\dots$ or $P(X \leq 1) = 0.5578$ M1 for writing $1 - P(Y \leq 1)$ or $1 - 0.5578$ (Condone use of X or any other letter) A1 for awrt 0.442 (correct answer only scores 3/3)	
(d)	1 st M1 for using a normal approximation with $\mu = 72$ 1 st A1 for $\mu = 72$ and $\sigma^2 = 72$ or $\sigma = \sqrt{72}$ These may be seen in a standardised expression 2 nd M1 Using 80.5 or 79.5 3 rd M1 standardising using 79.5, 80.5 or 80 with their mean and their standard deviation	

Question Number	Scheme	Marks
<p>2. (a)(i)</p> <p>(ii)</p> <p>(b)</p> <p>(c)</p>	$120(p)^3(1-p)^7$ $[10C3](p)^3(1-p)^7 = [10C7]16(p)^7(1-p)^3 \text{ or their (a)(i) } = [10C7]16(p)^7(1-p)^3$ $(1-p)^4 = 16(p)^4 \Rightarrow (1-p) = 2(p)$ $p = \frac{1}{3}$ $\frac{e^{-\lambda} \lambda^3}{3!} = 5 \frac{e^{-\lambda} \lambda^5}{5!}$ $4 = \lambda^2$ $\lambda = 2$ $np = 32$ $n = 80$ $\alpha = 19.2$	<p>B1</p> <p>M1</p> <p>M1</p> <p>A1</p> <p>(4)</p> <p>M1</p> <p>M1</p> <p>A1</p> <p>(3)</p> <p>M1</p> <p>A1</p> <p>A1</p> <p>(3)</p> <p>[10]</p>
Notes		
<p>(a)(i)</p> <p>(ii)</p> <p>NB1</p> <p>NB2</p> <p>(b)</p> <p>NB1</p> <p>NB2</p> <p>(c)</p>	<p>B1 Allow equivalent expressions e.g. $10C3(p)^3(1-p)^{10-3}$</p> <p>1st M1 correct equation fit their (a)(i) (condone missing binomial coefficients) but 16 must be on the correct side. Condone numerical slips.</p> <p>2nd M1 attempt to solve their equation as far as a linear equation in p. Condone numerical slips but they must deal with the algebraic terms correctly.</p> <p>A1 for $\frac{1}{3}$ or an exact equivalent. Allow 3/3 for correct answer only in (ii)</p> <p>If the 16 is on the wrong side they should get $p = \frac{2}{3}$ and score M0M1A0</p> <p>If there is no 16, or the 16 disappears, and they get $p = 0.5$ they score 2nd M1 A0</p> <p>1st M1 correct equation</p> <p>2nd M1 attempt to solve their equation as far as $\lambda^2 = k$ or $\lambda = \sqrt{k}$. Allow numerical slips.</p> <p>A1 for $\lambda = 2$ only</p> <p>If the 5 is on the wrong side they should get $\lambda = 10$ and score M0M1A0</p> <p>If there is no 5, or the 5 disappears, and they get $\lambda^2 = 20$ or $\lambda = \sqrt{20} = 2\sqrt{5}$ they score 2nd M1 A0</p> <p>M1 use of $np = 32$ Allow any value of p provided $0 < p < 1$</p> <p>1st A1 $n = 80$</p> <p>2nd A1 $\alpha = 19.2$</p>	

Question Number	Scheme	Marks		
<p>3. (a)</p> <p>(b)</p> <p>(c)</p> <p>(d)(i)</p> <p>(ii)</p>	<p>$P(X \leq 7) = 0.8883$ or $P(X \leq 8) = 0.9644$ or $P(X \geq 8) = 0.1117$ or $P(X \geq 9) = 0.0356$ Critical Region is $X \geq 9$ (o.e.)</p> <p>$(1 - 0.9644 =) 0.0356$ [NB Calculator gives: 0.03557486...]</p> <p>Reject H_0/Significant <u>or</u> value of p is > 0.45</p> <p>Conclusion would not change as H_0 would still be rejected</p> <p>Conclusion would change as H_0 would not be rejected</p>	<p>M1</p> <p>A1</p> <p>(2)</p> <p>B1cao</p> <p>(1)</p> <p>B1ft</p> <p>(1)</p> <p>B1</p> <p>B1</p> <p>(2)</p> <p>[6]</p>		
Notes				
<p>(a)</p> <p>(b)</p> <p>(c)</p> <p>(d)</p> <p>(i)</p> <p>(ii)</p> <p>CR</p>	<p>M1 for one of these 4 probabilities - may be implied by a correct critical region</p> <p>A1 for $X \geq 9$ (allow $X > 8$) (o.e.) e.g. [9, 12], {9, 10, 11, 12} etc Ans. only 2/2 NB Must be $X \geq 9$ for A1, do not award for just seeing $P(X \geq 9)$</p> <p>B1 for 0.0356 or better</p> <p>B1f ft their critical region in (a) Must say “reject” and “H_0” No contradictory statements Just saying “9 is not in the critical region” is <u>not</u> enough Allow a restart i.e. calculating $P(X \geq 9) = 0.0356 < 0.05$ so significant</p> <p style="text-align: center;">If they score B0 in (c) then score B0B0 in (d)</p> <table border="0" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; vertical-align: top;"> <p>In (c) they reject H_0</p> <p>B1 for “No”, “no change”, “significant” etc</p> <p>B1 for “Yes”, “do not reject H_0” etc</p> </td> <td style="width: 50%; vertical-align: top; border-left: 1px solid black; padding-left: 10px;"> <p>In (c) they accept H_0</p> <p>B0 whatever they say</p> <p>B1 for “no change” or “do not reject H_0” etc</p> </td> </tr> </table> <p>(i) NB new CR is $X \geq 9$ but can treat any incorrect mention of CR as ISW</p> <p>(ii) NB new CR is $X \geq 10$ but can treat any incorrect mention of CR as ISW</p>	<p>In (c) they reject H_0</p> <p>B1 for “No”, “no change”, “significant” etc</p> <p>B1 for “Yes”, “do not reject H_0” etc</p>	<p>In (c) they accept H_0</p> <p>B0 whatever they say</p> <p>B1 for “no change” or “do not reject H_0” etc</p>	
<p>In (c) they reject H_0</p> <p>B1 for “No”, “no change”, “significant” etc</p> <p>B1 for “Yes”, “do not reject H_0” etc</p>	<p>In (c) they accept H_0</p> <p>B0 whatever they say</p> <p>B1 for “no change” or “do not reject H_0” etc</p>			

Question Number	Scheme	Marks
<p>4. (a)</p> <p>(b)</p> <p>(c)</p> <p>(d)</p> <p>(e)</p> <p>(f)</p>	<p>(Continuous) Uniform/Rectangular</p> <p>$[\frac{1}{5}(5-2)] = \frac{3}{5}$ (o.e.)</p> <p>$P(X > 6) = p$ where $p = \frac{1}{5}$ or $\frac{7-6}{7-2}$ o.e. $Y =$ number of flights with a waiting time more than 6 minutes $[P(Y \geq 1) = 1 - P(Y = 0)] = 1 - (1 - p)^5 = 1 - (\frac{4}{5})^5 = 0.67232$ awrt 0.672</p> <p>$\int_2^x \frac{1}{5} dt = \left[\frac{t}{5} \right]_2^x$ or $\frac{x}{5} + c$ and $\frac{7}{5} + c = 1$ or $\frac{2}{5} + c = 0$</p> $F(x) = \begin{cases} 0 & x < 2 \\ \frac{x-2}{5} & 2 \leq x \leq 7 \\ 1 & x > 7 \end{cases}$ <p>Shape (single straight line of positive gradient wholly above x-axis) With or without a horizontal line (“lid”) Correct sketch with labels 2, 7 on x-axis and 1 on y-axis (With or without “lid”)</p> <p>(Mean = $\frac{2+7}{2} = 4.5$) So on foggy days, Mean = 6.5 and Variance = $\frac{(7-2)^2}{12} = \frac{25}{12}$ or awrt 2.08</p>	<p>B1 (1)</p> <p>B1 (1)</p> <p>M1 M1, A1 (3)</p> <p>M1</p> <p>A1 B1 (3)</p> <p>B1 dB1 (2)</p> <p>B1 M1 A1 (3)</p> <p>[13]</p>
Notes		
<p>(c)</p> <p>(d)</p> <p>(e)</p> <p>(f)</p>	<p>1st M1 for $P(X > 6) = \frac{1}{5}$ o.e. 2nd M1 correct expression of the form $1 - (1 - p)^5$ ft their $p = P(X > 6)$ provided $0 < p < 1$</p> <p>M1 for correct integration and sight of correct limits or integrating with $+ c$ and attempt to use $F(7) = 1$ or $F(2) = 0$ A1 for second line correct with correct limits. Allow $<$ instead of \leq B1 for first and third lines correct with correct limits. Allow \leq and \geq instead of $<$ and $>$</p> <p>2nd dB1 dependent on the first B1 for correct sketch with the 2, 7 and 1 in the correct places</p> <p>M1 a correct expression for $\text{Var}(X) = \frac{(7-2)^2}{12}$ or $\frac{(9-4)^2}{12}$ or $\int_{\alpha}^{\beta} \frac{1}{5} x^2 dx - \mu^2$ If $\mu = 4.5$ use $[2, 7]$ for $\mu = 6.5$ use $[4, 9]$ but no other cases. A1 for $\frac{25}{12}$ or awrt 2.08 do not isw [Answers only full marks]</p>	

Question Number	Scheme	Marks
<p>5. (a)</p> <p>(b)</p>	<p>(1, 1), (1, 5)[x2] (5, 5), (1, 10)[x2], (5, 10)[x2], (10, 10)</p> <p>e.g. (1, 5) and (5, 1) counts once only</p> <p>[For $M = 1, (1, 1)$] $q \times q = \frac{1}{25}, \quad q = \frac{1}{5}$</p> <p>[For $M = 5, (1, 5), (5, 1), (5, 5)$] $qr + rq + r^2 = \frac{13}{80}$</p> <p>$r^2 + 2(\frac{1}{5})r - \frac{13}{80} = 0 \rightarrow r = \frac{-\frac{2}{5} + \sqrt{(\frac{2}{5})^2 - 4(-\frac{13}{80})}}{2} \rightarrow r = \frac{1}{4}$</p> <p>[For $M = 10, (1, 10), (10, 1), (5, 10), (10, 5), (10, 10)$]</p> <p>$2qs + 2rs + s^2 = \frac{319}{400}$ or $q + r + s = 1$</p> <p>$s = \frac{11}{20}$</p>	<p>B2</p> <p>(2)</p> <p>M1, A1</p> <p>M1</p> <p>M1 A1</p> <p>M1</p> <p>A1</p> <p>(7)</p> <p>[9]</p>
Notes		
<p>(a)</p> <p>(b)</p> <p>SC</p> <p>epen</p>	<p>B2 all 6 pairs correct, ignore duplicates [e.g. (1, 5) and (5, 1)] but no incorrect pairs seen (B1 at least 4 correct pairs. Do not include duplicates but can ignore any incorrect pairs)</p> <p>For M marks can ft q and r but only if they are probabilities</p> <p>1st M1 a correct equation to find q</p> <p>1st A1 $q = \frac{1}{5}$ oe</p> <p>2nd M1 attempt at equation for r with q[ft their q] (condone 1 missing term but no extras)</p> <p>3rd M1 attempt to solve 3TQ (formula, completing the square or factorising see below)</p> <p>2nd A1 $r = \frac{1}{4}$ oe</p> <p>4th M1 correct equation for s, ft their q and their r or use of sum of probabilities = 1 but must have values for q and r ft their q and r</p> <p>3rd A1 $s = \frac{11}{20}$ oe</p> <p><u>Solving 3TQ</u> Formula: If correct formula is quoted allow 1 slip, otherwise correct expr' for their equation Complete Sq: i.e. $(r + \frac{1}{5})^2 - \frac{1}{25} - \frac{13}{80} = 0$ Allow 1 slip and ft their equation Factorise: Must multiply out to give "ends [inc. sign]" or "middle term" of their equation</p> <p>B1 for $\frac{q}{q+r+s} = \frac{1}{5}, \quad$ B1 for $\frac{r}{q+r+s} = \frac{1}{4}, \quad$ B1 for $\frac{s}{q+r+s} = \frac{11}{20}$</p> <p>1st M0 1st A1 2nd M0 3rd M0 2nd A1 4th M0 3rd A1</p>	

Question Number	Scheme	Marks
<p>6. (a)</p> <p>(b)</p> <p>(c)</p> <p>(d)</p>	$\frac{d}{dx}(ax - bx^2) = a - 2bx$ $a - 2b(1) = 0$ $a = 2b$ $\int_{[0]}^{[2]} (ax - bx^2) dx = 1$ $\left[\left(\frac{ax^2}{2} - \frac{bx^3}{3} \right) \right]_0^2 = 1$ $\frac{(2b)(2^2)}{2} - \frac{b(2^3)}{3} = 1$ $a = \frac{3}{2} \quad b = \frac{3}{4}$ $\int_0^{1.5} f(x) dx = \left[\left(\frac{ax^2}{2} - \frac{bx^3}{3} \right) \right]_0^{1.5}$ $= \frac{\frac{3}{2}(1.5)^2}{2} - \frac{(\frac{3}{4})(1.5)^3}{3} = \frac{27}{32}$ $\frac{27}{32} \text{ or awrt } \underline{\underline{0.844}}$ <p>F(1.5) > 0.75, Therefore the upper quartile of X is less than 1.5</p>	<p>M1</p> <p>A1cso (2)</p> <p>M1</p> <p>A1</p> <p>dM1 A1 A1 (5)</p> <p>M1</p> <p>A1 (2)</p> <p>M1</p> <p>A1ft (2)</p> <p>[11]</p>
Notes		
<p>Beware</p> <p>(a)</p> <p>(b)</p> <p>(c)</p> <p>(d)</p> <p>Find Q₃</p>	<p>M1 differentiating f(x) at least one of $x^n \rightarrow x^{n-1}$, must lead to a function of x. May complete the square (M1 when $x = \frac{a}{2b}$). Use of “$-\frac{b}{2a}$” must quote this and get M1 for $1 = \frac{a}{2b}$</p> <p>A1cso fully correct solution with no errors seen</p> <p>Use of f(2) = 0 scores M0A0. [Send argument based on f(x) = 0 to review.]</p> <p>1st M1 attempt to integrate and equate to 1 (at least one $x^n \rightarrow x^{n+1}$) Ignore limits.</p> <p>1st A1 correct integration (in terms of a or b or both) and sight of correct limits</p> <p>NB sight of $2a - \frac{8}{3}b = 1$ (which is equivalent to F(2) = 1) scores the first M1A1</p> <p>2nd dM1 for use of correct limits (at least $x = 2$ must be seen) and substituting $a = 2b$ to obtain an equation in 1 variable (dependent on previous M1)</p> <p>M1 for use of F(1.5) or $\int_0^{1.5} f(x) dx$ (at least one $x^n \rightarrow x^{n+1}$) with limits and ft their a and b</p> <p>M1 for a correct comparison of their F(1.5) with 0.75</p> <p>M1 if they attempt F(x) = 0.75 and get Q₃ = awrt 1.35 (calc 1.347296...) and A1 for conc'1</p> <p>A1ft for correct conclusion (follow through their value of F(1.5) provided $0.5 < F(1.5) < 1$)</p>	

Question Number	Scheme	Marks
<p>7. (a)(i)</p> <p>(ii)</p> <p>(b)</p> <p>(c)</p> <p>(d)</p>	<p>$\sqrt{n(0.04)(1-0.04)} = 1.44$ or $n(0.04)(1-0.04) = 1.44^2$</p> <p>$0.0384n = 2.07(36),$ $n = 54$</p> <p>mean = $54 \times 0.04 = 2.16$ or $\frac{54}{25}$</p> <p>$[(0.96)^{20}] = 0.44200\dots$ awrt 0.442</p> <p>$X \sim B(20, 0.04)$</p> <p>$[P(X = 3 X \geq 1)] = \frac{P(X = 3)}{P(X \geq 1)}$</p> <p>$= \frac{20C3(0.04)^3(0.96)^{17}}{1 - (0.96)^{20}}$ or $\frac{20C3(0.04)^3(0.96)^{17}}{1 - \text{their (b)}} = 0.065322\dots$ awrt 0.0653</p> <p>$H_0: p = 0.04$ $H_1: p > 0.04$</p> <p>$[X \sim B(125, 0.04)]$ Po(5)</p> <p>$P(X \geq 10) = 1 - P(X \leq 9)$ or $P(X \leq 9) = 0.9682$</p> <p>$= 1 - 0.9682$ $P(X \geq 10) = 0.0318$</p> <p>$= 0.0318$ CR $X \geq 10$</p> <p>Reject H_0 or Significant or 10 lies in the Critical region.</p> <p>Evidence that <u>proportion/number/rate/%/probability</u> of <u>cars failing</u> the <u>test</u> is <u>more ...</u> <u>or the car mechanic's claim is supported.</u></p>	<p>M1</p> <p>dM1, A1</p> <p>B1cao</p> <p>(4)</p> <p>B1</p> <p>(1)</p> <p>B1</p> <p>M1</p> <p>dM1 A1</p> <p>(4)</p> <p>B1</p> <p>B1</p> <p>M1</p> <p>A1</p> <p>dM1</p> <p>A1cso (6)</p> <p>[15]</p>
Notes		
<p>(a)(i)</p> <p>(c)</p> <p>(d)</p> <p>Normal Two-Tail</p>	<p>M1 use of s.d. = $\sqrt{np(1-p)} = 1.44$ with a value of p in (0, 1) or equation with variance</p> <p>dM1 dep on 1st M1 for solving equation as far as $an = 2.07(36)$ or $n = \frac{1.44^2}{a}$ (Ans only 3/3)</p> <p>B1 for writing or using B(20, 0.04). May be implied by e.g. $P(X = 3) = 0.036449\dots$ (Allow 3 sf)</p> <p>1st M1 for a correct ratio expression for conditional prob. $P(X \geq 1)$ may be $1 - P(X = 0)$</p> <p>2nd M1 dep on first M1 for correct attempt at either $P(X = 3)$ or $P(X \geq 1)$ (may ft (b)) (Ans only 4/4)</p> <p>B1 for both hypotheses correct (p or π) (Allow $H_0: \lambda = 5$ $H_1: \lambda > 5$) [\geq is B0]</p> <p>B1 for <u>using</u> Po(5) (May need to check tables e.g. $P(X \leq 10) = 0.9863$ would imply B1)</p> <p>1st M1 for writing or using $1 - P(X \leq 9)$ or giving $P(X \leq 9) = 0.9682$ or $P(X \geq 10) = 0.0318$</p> <p>1st A1 for 0.0318 or CR $X \geq 10$ [either of these scores the M1A1]</p> <p>2nd dM1 for correct statement based on their prob and 0.05 or 10 and their CR. (i.e. Reject H_0/Significant/10 lies in the Critical region) May be implied by a correct contextual statement.</p> <p>Dep on 1st M1. Do not allow contradictory statements e.g. "significant, accept H_0"</p> <p>2nd A1cso for a correct contextual conclusion and no errors seen.</p> <p>(can score B1B0M1A0M1A0) 1st M1 for $P(X \geq 10)$ and standardising with 9.5 or 10.5</p> <p>Allow max of: B0B1M1A1 (2 for CR of $X \geq 11$ otherwise 0) dM1 (for accepting H_0) A0cso</p>	

