edexcel

Mark Scheme (Final)

Summer 2016

Pearson Edexcel International A Level Statistics 2

(WST02/01)

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications come from Pearson, the world's leading learning company. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information, please visit our website at www.edexcel.com.

Our website subject pages hold useful resources, support material and live feeds from our subject advisors giving you access to a portal of information. If you have any subject specific questions about this specification that require the help of a subject specialist, you may find our Ask The Expert email service helpful.

www.edexcel.com/contactus

Pearson: helping people progress, everywhere

Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

Summer 2016
Publications Code WST02_1606_MS

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 $\surd$ 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
- ⌐ 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.

Special notes for marking Statistics exams (for AAs only)

- If a method leads to “probabilities” which are greater than 1 or less than 0 then M0 should be awarded unless the mark scheme specifies otherwise.
- Any correct method should gain credit. If you cannot see how to apply the mark scheme but believe the method to be correct then please send to review.
- For method marks, we generally allow or condone a slip or transcription error if these are seen in an expression. We do not, however, condone or allow these errors in accuracy marks.
- If a candidate is “hedging their bets” e.g. give Attempt 1…Attempt 2…etc then please send to review.

WST02 June 2016 Final

Question Number	Scheme	Marks
1. (a)	$(X \sim \text{Po}(9), \text{P}(X \leqslant 10) = 0.7060)$	
	$v = 11$ [Not $v > 11$ or any inequality]	**B1**
		(1)
(b)	$\text{P}(4 \leqslant X \leqslant 11) = \text{P}(X \leqslant 11) - \text{P}(X \leqslant 3)$	**M1**
	$0.8030 - 0.0212 = 0.7818$ awrt **0.782**	**A1**
		(2)
(c)	Po(1.5)	**B1**
	$\text{P}(Y > 1) = 1 - \text{P}(Y \leqslant 1)$ or $1 - 0.5578$	**M1**
	$= 0.4422$ awrt **0.442**	**A1**
		(3)
(d)	[Let W = number of visits to the school website in 8 hours.]	
	$W \sim \text{Po}(72)$ approximately N(72, 72)	**M1 A1**
	$\text{P}(W > 80) = \text{P}\left(Z > \frac{80.5 - 72}{\sqrt{72}}\right)$	**M1 M1**
	$= \text{P}(Z > 1.00....)$	
	$= 0.1587$ (or 0.15824 from calculator) awrt **0.159/0.158**	**A1**
		(5)
		[11]

	Notes
(b)	M1 for writing or using $\text{P}(X \leqslant 11) - \text{P}(X \leqslant 3)$ May be implied by a correct answer.
(c)	B1 for writing or using Po(1.5) May be implied by $\text{P}(X = 0) = 0.2231$ or $\text{P}(X = 1) = 0.3346...$ or $\text{P}(X \leqslant 1) = 0.5578$ M1 for writing $1 - \text{P}(Y \leqslant 1)$ or $1 - 0.5578$ (Condone use of X or any other letter) A1 for awrt 0.442 (correct answer only scores 3/3)
(d)	1st M1 for using a normal approximation with $\mu = 72$ 1st A1 for $\mu = 72$ and $\sigma^2 = 72$ or $\sigma = \sqrt{72}$ These may be seen in a standardised expression 2nd M1 Using 80.5 or 79.5 3rd M1 standardising using 79.5, 80.5 or 80 with their mean and their standard deviation

Question Number	Scheme	Marks
2. (a)(i)	$120(p)^3(1-p)^7$	**B1**
(ii)	$[10C3](p)^3(1-p)^7 = [10C7]16(p)^7(1-p)^3$ <u>or</u> their (a)(i) $= [10C7]16(p)^7(1-p)^3$	**M1**
	$(1-p)^4 = 16(p)^4 \Rightarrow (1-p) = 2(p)$	**M1**
	$p = \frac{1}{3}$	**A1**
		(4)
(b)	$\frac{e^{-\lambda}\lambda^3}{3!} = 5\frac{e^{-\lambda}\lambda^5}{5!}$	**M1**
	$4 = \lambda^2$	**M1**
	$\lambda = 2$	**A1**
		(3)
(c)	$np = 32$ $n = 80$ $\alpha = 19.2$	**M1** **A1** **A1**
		(3)
		[10]

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

Question Number	Scheme	Marks
3. (a)	$P(X \leqslant 7) = 0.8883$ or $P(X \leqslant 8) = 0.9644$ or $P(X \geqslant 8) = 0.1117$ or $P(X \geqslant 9) = 0.0356$	**M1**
	Critical Region is $X \geqslant 9$ (o.e.)	**A1**
		(2)
(b)	(1 – 0.9644=) 0.0356 [NB Calculator gives: 0.03557486...]	**B1cao**
		(1)
(c)	Reject H_0/Significant or value of p is > 0.45	**B1ft**
		(1)
(d)(i)	Conclusion would not change as H_0 would still be rejected	**B1**
(ii)	Conclusion would change as H_0 would not be rejected	**B1**
		(2)
		[6]

Notes

(a)
M1 for one of these 4 probabilities - may be implied by a correct critical region
A1 for $X \geqslant 9$ (allow $X > 8$) (o.e.) e.g. [9, 12], {9, 10, 11, 12} etc Ans. only 2/2
NB Must be $X \geqslant 9$ for A1, do not award for just seeing $P(X \geqslant 9)$

(b)
B1 for 0.0356 or better

(c)
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 not enough
Allow a restart i.e. calculating $P(X \geqslant 9) = 0.0356 < 0.05$ so significant

If they score B0 in (c) then score B0B0 in (d)

(d)	In (c) they reject H_0	In (c) they accept H_0
(i)	B1 for "No", "no change", "significant" etc	B0 whatever they say
(ii)	B1 for "Yes" , "do not reject H_0" etc	B1 for "no change" or "do not reject H_0" etc

CR
(i) NB new CR is $X \geqslant 9$ but can treat any incorrect mention of CR as ISW
(ii) NB new CR is $X \geqslant 10$ but can treat any incorrect mention of CR as ISW

Question Number	Scheme	Marks
4. (a)	(Continuous) Uniform/Rectangular	**B1** **(1)**
(b)	$[\frac{1}{5}(5-2)]=\frac{3}{5}$ (o.e.)	**B1** **(1)**
(c)	$P(X>6)=p$ 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 $\left[P(Y\geqslant 1)=1-P(Y=0)\right]=1-(1-p)^5=1-(\frac{4}{5})^5=$, 0.67232 awrt **0.672**	**M1** **M1, A1** **(3)**
(d)	$\int_2^x \frac{1}{5}\,dt=\left[\frac{t}{5}\right]_2^x$ or $\frac{x}{5}+c$ and $\frac{7}{5}+c=1$ or $\frac{2}{5}+c=0$ $F(x)=\begin{cases}0 & x<2\\ \frac{x-2}{5} & 2\leqslant x\leqslant 7\\ 1 & x>7\end{cases}$	**M1** **A1** **B1** **(3)**
(e)	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")	**B1** **dB1** **(2)**
(f)	(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**	**B1** **M1 A1** **(3)** **[13]**

	Notes
(c)	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 $0 < p < 1$
(d)	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 $\leqslant$ B1 for first and third lines correct with correct limits. Allow $\leqslant$ and $\geqslant$ instead of < and >
(e)	2nd dB1 dependent on the first B1 for correct sketch with the 2, 7 and 1 in the correct places
(f)	M1 a correct expression for Var(X) $=\frac{(7-2)^2}{12}$ or $\frac{(9-4)^2}{12}$ or $\int_\alpha^\beta \frac{1}{5}x^2dx-\mu^2$ 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]

Question Number	Scheme	Marks
5. (a)	(1, 1), (1, 5)[x2] (5, 5), e.g. (1, 5) and (5, 1) counts once only (1, 10)[x2], (5, 10)[x2], (10, 10)	**B2** **(2)**
(b)	[For M = 1, (1, 1)] $q \times q = \frac{1}{25}$, $q = \frac{1}{5}$	**M1, A1**
	[For M = 5, (1, 5), (5, 1), (5, 5)] $qr + rq + r^2 = \frac{13}{80}$	**M1**
	$r^2 + 2(\frac{1}{5})r - \frac{13}{80} = 0 \rightarrow r = \frac{-\frac{2}{5} + \sqrt{(\frac{2}{5})^2 - 4(-\frac{13}{80})}}{2} \rightarrow r = \frac{1}{4}$	**M1 A1**
	[For M = 10, (1, 10), (10, 1), (5, 10), (10, 5), (10, 10)]	
	$2qs + 2rs + s^2 = \frac{319}{400}$ or $q + r + s = 1$	**M1**
	$s = \frac{11}{20}$	**A1** **(7)** **[9]**

	Notes
(a)	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) **For M marks can ft *q* and *r* but only if they are probabilities**
(b)	1st M1 a correct equation to find q 1st A1 $q = \frac{1}{5}$ oe 2nd M1 attempt at equation for r with q[ft their q] (condone 1 missing term but no extras) 3rd M1 attempt to solve 3TQ (formula, completing the square or factorising see below) 2nd A1 $r = \frac{1}{4}$ oe 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 3rd A1 $s = \frac{11}{20}$ oe Solving 3TQ **Formula:** If correct formula is quoted allow 1 slip, otherwise correct expr' for their equation **Complete Sq:** i.e. $\left(r + \frac{1}{5}\right)^2 - \frac{1}{25} - \frac{13}{50} = 0$ Allow 1 slip and ft their equation **Factorise:** Must multiply out to give "ends [inc. sign]" or "middle term" of their equation
SC epen	B1 for $\frac{q}{q+r+s} = \frac{1}{5}$, 1st M0 1st A1 B1 for $\frac{r}{q+r+s} = \frac{1}{4}$, 2nd M0 3rd M0 2nd A1 B1 for $\frac{s}{q+r+s} = \frac{11}{20}$ 4th M0 3rd A1

Question Number	Scheme	Marks
6. (a)	$\frac{\mathrm{d}}{\mathrm{d}x}\left(ax-bx^2\right)=a-2bx$	**M1**
	$a-2b(1)=0$	**A1cso**
	$a=2b$	**(2)**
(b)	$\int_{[0]}^{[2]}(ax-bx^2)\,\mathrm{d}x=1$	**M1**
	$\left[\left(\frac{ax^2}{2}-\frac{bx^3}{3}\right)\right]_0^2=1$	**A1**
	$\frac{(2b)(2^2)}{2}-\frac{b(2^3)}{3}=1$ $\quad$ $\underline{a=\frac{3}{2}}$ $\quad$ $\underline{\underline{b=\frac{3}{4}}}$	**dM1 <u>A1</u> <u>A1</u>**
		(5)
(c)	$\int_0^{1.5}\mathrm{f}(x)\mathrm{d}x=\left[\left(\frac{ax^2}{2}-\frac{bx^3}{3}\right)\right]_0^{1.5}$	**M1**
	$=\frac{\frac{3}{2}(1.5)^2}{2}-\frac{(\frac{3}{4})(1.5)^3}{3}=\frac{27}{32}$ $\quad$ $\underline{\frac{27}{32}}$ or awrt **<u>0.844</u>**	**A1**
		(2)
(d)	F(1.5) > 0.75,	**M1**
	Therefore the upper quartile of X is less than 1.5	**A1ft (2)**
		[11]

	Notes
(a)	M1 differentiating f(x) at least one of $x^n \to x^{n-1}$, 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 $1=\frac{a}{2b}$
	A1cso fully correct solution with no errors seen
Beware	Use of f(2) = 0 scores M0A0. [Send argument based on f(x) = 0 to review.]
(b)	1st M1 attempt to integrate and equate to 1 (at least one $x^n \to x^{n+1}$) Ignore limits.
	1st A1 correct integration (in terms of a or b or both) and sight of correct limits
	NB sight of $2a-\frac{8}{3}b=1$ (which is equivalent to F(2) = 1) scores the first M1A1
	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)
(c)	M1 for use of F(1.5) <u>or</u> $\int_0^{1.5}\mathrm{f}(x)\mathrm{d}x$ (at least one $x^n \to x^{n+1}$) with limits and ft their a and b
(d)	M1 for a correct comparison of their F(1.5) with 0.75
Find Q_3	M1 if they attempt F(x) = 0.75 **and** get Q_3 = awrt 1.35 (calc 1.347296...) and A1 for conc'l
	A1ft for correct conclusion (follow through their value of F(1.5) provided 0.5 < F(1.5) < 1)

Question	Scheme	Marks

Number		
7. (a)(i)	$\sqrt{n(0.04)(1-0.04)} = 1.44$ or $n(0.04)(1-0.04) = 1.44^2$	**M1**
	$0.0384n = 2.07(36)$, $n = 54$	**dM1, A1**
(ii)	mean $= 54 \times 0.04 = 2.16$ or $\frac{54}{25}$	**B1cao**
		(4)
(b)	$[(0.96)^{20}] = 0.44200\ldots$ awrt **0.442**	**B1**
		(1)
(c)	$X \sim B(20, 0.04)$	**B1**
	$\left[P(X = 3 \mid X \geqslant 1) = \right] \frac{P(X=3)}{P(X \geqslant 1)}$	**M1**
	$= \frac{20C3(0.04)^3(0.96)^{17}}{1-(0.96)^{20}}$ or $\frac{20C3(0.04)^3(0.96)^{17}}{1-\text{ their (b)}} = 0.065322...$ awrt **0.0653**	**dM1 A1**
		(4)
(d)	H_0: $p = 0.04$ H_1: $p > 0.04$	**B1**
	$[X \sim B(125, 0.04)]$ Po(5)	**B1**
	$P(X \geqslant 10) = 1 - P(X \leqslant 9)$ or $P(X \leqslant 9) = 0.9682$	**M1**
	$= 1 - 0.9682$ $P(X \geqslant 10) = 0.0318$	
	$= 0.0318$ CR $X \geqslant 10$	**A1**
	Reject H_0 or Significant or 10 lies in the Critical region.	**dM1**
	Evidence that proportion/number/rate/%/probability of cars failing the test is more ... **or** the car mechanic's claim is supported.	**A1cso (6)**
		[15]

	Notes
(a)(i)	M1 use of s.d. = $\sqrt{np(1-p)} = 1.44$ with a value of p in (0, 1) or equation with variance
	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)
(c)	B1 for writing or using B(20, 0.04). May be implied by e.g. $P(X = 3) = 0.036449$..(Allow 3 sf)
	1st M1 for a correct ratio expression for conditional prob. $P(X \geqslant 1)$ may be $1 - P(X = 0)$
	2nd M1 dep on first M1 for correct attempt at either $P(X = 3)$ or $P(X \geqslant 1)$ (may ft (b)) (Ans only 4/4)
(d)	B1 for both hypotheses correct (p or π) (Allow H_0: $\lambda = 5$ H_1: $\lambda > 5$) [$\geqslant$ is B0]
	B1 for using Po(5) (May need to check tables e.g. $P(X \leqslant 10) = 0.9863$ would imply B1)
	1st M1 for writing or using $1 - P(X \leqslant 9)$ or giving $P(X \leqslant 9) = 0.9682$ or $P(X \geqslant 10) = 0.0318$
	1st A1 for 0.0318 or CR $X \geqslant 10$ [either of these scores the M1A1]
	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. Dep on 1st M1. Do not allow contradictory statements e.g. "significant, accept H_0"
	2nd A1cso for a correct contextual conclusion and no errors seen.
Normal	(can score B1B0M1A0M1A0) 1st M1 for $P(X \geqslant 10)$ and standardising with 9.5 or 10.5
Two-Tail	Allow max of: B0B1M1A1 (2 for CR of $X \geqslant 11$otherwise 0) dM1 (for accepting H_0) A0cso

Pearson Education Limited. Registered company number 872828
with its registered office at Edinburgh Gate, Harlow, Essex CM20 2JE