Mark Scheme (Results)

January 2017

Pearson Edexcel
International A-Level Mathematics

Statistics 2 (WST02)

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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 $\sqrt{}$ 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
- $\ast$ The answer is printed on the paper
- $\sqsubset$ 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.

January 2017 IAL
WST02/01 Statistics 2
Mark Scheme

Question Number	Scheme	Marks
1.	$W \sim \mathrm{N}(32, 16)$, $X \sim \mathrm{Bin}(20, 0.45)$	
(a)	$\{\mathrm{P}(W = 36)\} = \underline{0}$ **<u>0</u>**	B1
		[1]
(b)	$\{\mathrm{P}(X = 8)\} = \mathrm{P}(X \leqslant 8) - \mathrm{P}(X \leqslant 7)$ <u>or</u> ${}^{20}C_8(0.45)^8(1-0.45)^{12}$	M1
	$= 0.1623003713...$ awrt **<u>0.162</u>**	A1
		[2]
(c)	$\{\mu = \mathrm{E}(X) = 20(0.45) \Rightarrow\}$ $\mathrm{E}(X) = 9$	B1
	$\sigma = \sqrt{20(0.45)(1-0.45)}$ $\{= 2.2248595...\}$	M1
	$\{\text{prob} =\}$ $\mathrm{P}\left(9 - \sqrt{4.95} < X < 9 + \sqrt{4.95}\right) = \mathrm{P}(X \le 11) - \mathrm{P}(X \le 6)$	dM1
	$\{0.8692 - 0.1299\} = 0.7393$ awrt **<u>0.739</u>**	A1
		[4]
		7
	Notes	
(b)	**M1** for writing or using $\mathrm{P}(X \leqslant 8) - \mathrm{P}(X \leqslant 7)$ (may be implied by 0.4143 – 0.2520) <u>or</u> for a correct expression ${}^{20}C_8(0.45)^8(1-0.45)^{12}$	
(c)	**B1** $\mathrm{E}(X) = 9$ seen or implied **1st M1** writing or using $\sigma = \sqrt{20(0.45)(1-0.45)}$ **2nd M1** dependent upon 1st M1 for correct use of $\mathrm{P}(\mu - \sigma < X < \mu + \sigma) = \mathrm{P}(X \le A) - \mathrm{P}(X \le B)$ with A and B correct for their μ and σ Special Case: $\mathrm{P}(9 - 4.95 < X < 9 + 4.95) = \mathrm{P}(X \le 13) - \mathrm{P}(X \le 4)$ [=awrt 0.960] scores B1M0M1A0	

Question Number	Scheme	Marks
2. (a)	$\left\{\mathrm{E}(X)=8 \Rightarrow\right\}\ \dfrac{\beta+\alpha}{2}=8$	B1
		[1]
(b)	$\left\{\mathrm{P}(X \leqslant 13)=0.7 \Rightarrow\right\}\left\{\text{or } \Rightarrow \mathrm{P}(8 \leqslant X \leqslant 13)=0.2\right\}$	
	$\dfrac{13-a}{b-a}=\dfrac{7}{10}$ <u>or</u> $\dfrac{\beta-13}{\beta-\alpha}=\dfrac{3}{10}$ <u>or</u> $\dfrac{13-8}{\beta-\alpha}=\dfrac{1}{5}$ <u>or</u> $\dfrac{13-8}{\beta-13}=\dfrac{0.2}{0.3}$ $\Rightarrow \alpha=$ or $\beta=$	M1
	$\left.\begin{array}{r}\beta+\alpha=16\\ 7\beta+3\alpha=130\end{array}\right\}\ \beta=20.5,\ \alpha=-4.5$ Either $a=-4.5$ **or** $b=20.5$	A1
	Both $\underline{\alpha=-4.5}$ **and** $\underline{\beta=20.5}$	A1
		[3]
(c)	$\left\{\mathrm{Var}(X)=\dfrac{(20.5--4.5)^2}{12}\right\}$ $\underline{\dfrac{625}{12}}$ or awrt $\underline{\mathbf{52.1}}$	B1 ft
		[1]
(d)	$\left\{\mathrm{P}(5 \leqslant X \leqslant 35)\right\}=\dfrac{20.5-5}{20.5--4.5}\left\{=\dfrac{15.5}{25}\right\}=\dfrac{31}{50}$ $\underline{\dfrac{31}{50}}$ or $\underline{\mathbf{0.62}}$	M1 A1
		[2] **7**

Notes

(a) **B1** for $\dfrac{\beta+\alpha}{2}=8$ o.e.

(b) **M1** for writing down a second equation in a and/or b **<u>and</u>** attempting to solve leading to a value of a or b

1st A1 one correct value

2nd A1 both correct values

(Correct answer only scores M1A1A1).

(c) **B1ft** allow follow through on their $\dfrac{(b-a)^2}{12}$

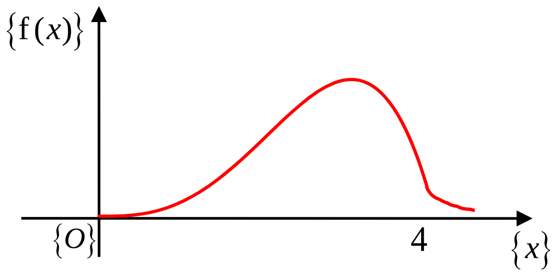
(d) **M1** for finding a probability in the form $\dfrac{a}{b}$ with $a=(\text{their } b)-5$ **and** $b=(\text{their } b)-(\text{their } a)$

or for $1-\dfrac{5-\text{their } \alpha}{\text{their } \beta-\text{their } \alpha}$

Question Number	Scheme	Marks
3.	Let Y = the number of reported first aid incidents	
(a)	λ/mean is large (greater than 10) $\quad\lambda$ is large	B1
		[1]
(b)	{For a 1 week period} $\quad Y \sim \text{Po}(3.5)$	
	$\text{P}(Y=3)=0.2158$ **and** $\text{P}(Y=4)=0.1888$ **or** states that 3 is the largest integer less than λ	B1
	$\left\{\text{As P}(Y=3)>\text{P}(Y=4),\right\}$ mode = 3 $\quad$ **<u>3</u>**	B1
		[2]
(c)	{For a 2 week period} $\quad X \sim \text{Po}(7)$ $\quad$ Po(7)	B1
	$\left\{\text{P}(X>5)\right\}=1-\text{P}(X\leqslant 5)$ or $1-0.3007$	M1
	$=0.6993$ $\quad$ awrt **<u>0.699</u>**	A1
		[3]
(d)	{For a 1 week period} $\quad Y \sim \text{Po}(3.5)$	
	$\dfrac{\text{P}(Y=4)\times\text{P}(Y=2)}{\text{P}(X=6)} = \dfrac{\left(\dfrac{e^{-3.5}(3.5)^4}{4!}\right)\left(\dfrac{e^{-3.5}(3.5)^2}{2!}\right)}{\left(\dfrac{e^{-7}(7)^6}{6!}\right)}$ or $\dfrac{(0.7254-0.5366)(0.3208-0.1359)}{0.4497-0.3007}$	M1(numerator) M1 A1
	$=\dfrac{15}{64}$ or 0.234375 $\quad$ $\underline{\dfrac{15}{64}}$ or awrt **<u>0.234</u>**	A1
		[4]
(e)	{For a 40 week period} $\quad Y \sim \text{Po}(140)$	
	{Approximation} $\quad Y \sim \text{N}(140,140)$ $\quad$ $\text{N}(140,140)$	M1 A1
	$=\text{P}\left(Z>\dfrac{119.5-140}{\sqrt{140}}\right)$	M1 M1
	$=\text{P}\left(Z>-1.732566...\right)$	A1
	$=0.9582$ $\quad$ awrt **<u>0.958</u>**	A1
		[6]
		16

Notes

(b)	**1st B1** $\text{P}(Y=3)=$ awrt 0.216 **and** $\text{P}(Y=4)=$ awrt 0.189 **or** states that 3 is the largest integer less than $\lambda=3.5$ **2nd B1** mode = 3 [Not dependent on 1st B1]
(c)	**B1** Po(7) seen or implied **M1** writing or using $1-\text{P}(X\le 5)$ (may be implied by $1-0.3007$)
(d)	**1st M1** for $\text{P}(Y=4)\times\text{P}(Y=2)$ using Po(3.5) (may be implied by awrt 0.189 × awrt 0.185 or awrt 0.0349) **2nd M1** correct use of conditional probability with denominator $\text{P}(X=6)$ from Po(7) **and** numerator $\text{P}(W=4)\times\text{P}(W=2)$ from $W\sim\text{Po}(\text{any }\lambda)$ **1st A1** fully correct numerical expression **2nd A1** awrt 0.234
(e)	**1st M1** for writing or using a normal approximation **1st A1** (140,140) (correct mean and variance which may be seen in standardisation) **2nd M1** for attempting to use the continuity correction (120 ± 0.5) **3rd M1** standardising using their mean and their sd on either $[119.5 \text{ or } 120 \text{ or } 120.5]$ **2nd A1** for $\dfrac{\pm(119.5-140)}{\sqrt{140}}$ (may be implied by z = awrt ±1.73) **3rd A1** awrt 0.958

Question Number	Scheme	Marks
4. (a)	$\{\mathrm{E}(X)=\}\ \int_0^2 x\frac{3}{64}x^2(4-x)\mathrm{d}x$	M1
	$=\frac{3}{64}\left[x^4-\frac{x^5}{5}\right]_0^4$	A1
	$=2.4$	A1
	So, mean number of hours is **<u>2400</u>**	A1ft
		[4]
(b)	$\{\mathrm{E}(X^2)=\}\ \int_0^2 x^2\frac{3}{64}x^2(4-x)\mathrm{d}x$	M1
	$=\frac{3}{64}\left[\frac{4x^5}{5}-\frac{x^6}{6}\right]_0^4\ \{=6.4\}$	A1
	$\sigma_x=\sqrt{6.4-(2.4)^2}\ =0.8$ **<u>0.8</u>**	dM1 A1 **[4]**
(c)	Some components may last longer than 4000 hours/ X could be greater than 4	B1
		[1]
(d)	Eg.  Sketch of a pdf with $x\geq 0$ and right end going beyond 4. Must be asymptotic or touch the x-axis beyond 4. Ignore labels of $\mathrm{f}(x)$, O and x.	B1
		[1]
		10

Notes

(a) **M1** using $\int x\mathrm{f}(x)\mathrm{d}x$ **and** attempting to integrate (At least one $x^n\to x^{n+1}$) Ignore limits.

1st A1 correct integration. Ignore limits.

2nd A1 2.4 o.e. (may be implied by a correct answer)

3rd A1ft dependent on the M mark for multiplying their E(X) by 1000 (allow 2.4 thousand)

(b) 1st M1 using $\int x^2\mathrm{f}(x)\mathrm{d}x$ **and** attempting to integrate (At least one $x^n\to x^{n+1}$) Ignore limits.

1st A1 correct integration. Ignore limits.

2nd M1 dependent on 1st M1 for use of $\sqrt{\text{'E}(X^2)\text{'}-\text{'E}(X)\text{'}^2}$

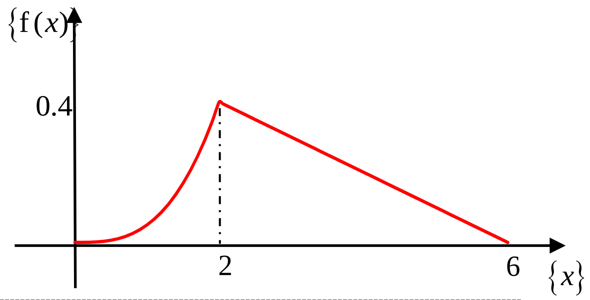
2nd A1 0.8 [Allow this mark to be scored for a standard deviation of 800 hours]

(c) **B1** for an appropriate comment that refers to 4000 hours/ X >4

Question Number	Scheme	Marks
5.	X = Number of defects , Y = Number of pieces of 15m^2 containing at most 7 defects	
(a)	$X \sim \text{Po}(6)$ per 15m^2	M1
	$\{p =\}$ $\text{P}(X \leqslant 7) = 0.7440$	A1
	$Y \sim \text{B}(12, 0.7440)$ per 15m^2	M1
	$\{\text{P}(Y=6) =\}$ ${}^{12}\text{C}_6(0.7440)^6(0.2560)^6$	M1
	$= 0.04411125...$ awrt **<u>0.044</u>**	A1
		[5]
(b)(i)	$\text{H}_0 : \lambda = 0.4,\ \text{H}_1 : \lambda \neq 0.4$ **or** $\text{H}_0 : \lambda = 2,\ \text{H}_1 : \lambda \neq 2$ **or** $\text{H}_0 : \lambda = 10,\ \text{H}_1 : \lambda \neq 10$	B1
(ii)	{X = } the <u>number/amount</u> of <u>defects</u> in a <u>25 m²</u> piece of cloth	B1
(iii)	The <u>set of/range of values for</u> the number of <u>defects</u> observed in a 25 m² piece of cloth that would lead you to <u>reject H₀</u>.	B1
		[3]
(c)	$X \sim \text{Po}(10)$ per 25m^2	B1
	$\text{P}(X \leqslant 3) = 0.0103$ $\text{P}(X \leqslant 4) = 0.0293$ $\text{P}(X \leqslant 16) = 0.9730$ or $\text{P}(X \geqslant 17) = 0.0270$ $\text{P}(X \leqslant 17) = 0.9857$ or $\text{P}(X \geqslant 18) = 0.0143$	M1
	CR: $X \leqslant 3$ or $X \geqslant 18$ o.e.	A1A1
		[4]
(d)	$\{\text{Actual sig. level} =\}$ $0.0103 + 0.0143$	M1
	$= 0.0246$ or 2.46% awrt **<u>0.0246</u>** or **<u>2.46%</u>**	A1
		[2]
		14

	Notes
(a)	**1st M1** writing or using Po(6) **1st A1** awrt 0.744 seen or implied **2nd M1** writing or using $Y \sim$ B(12, *their p*) **3rd M1** use of P(Y=6) from B(12, *their p*) i.e. ${}^{12}\text{C}_6(\text{"}p\text{"})^6(1-\text{"}p\text{"})^6$
(b)(i) **(ii)** **(iii)**	**B1** Both hypotheses correct. May use λ or μ **B1** Must include underlined words o.e. Allow Po(10) to imply 25m². Note: 'Rate' does not imply number/amount **B1** Must include underlined words o.e. Must be clear that the response refers to a set of values rather than a single value. Note: Do not allow 'region' for set/range
(c)	**B1** Po(10) seen or implied **M1** for one correct probability from Po(10): $\text{P}(X \leqslant 3) = 0.0103$ or $\text{P}(X \leqslant 4) = 0.0293$ or $\text{P}(X \leqslant 16) = 0.9730$ or $\text{P}(X \geqslant 17) = 0.0270$ or $\text{P}(X \leqslant 17) = 0.9857$ or $\text{P}(X \geqslant 18) = 0.0143$ **1st A1** either correct tail of the CR **2nd A1** fully correct CR (allow any letter(s) used instead of X) **SC**: an answer of P($X \leq 3$) and P($X \geq 18$) scores B1M1A1A0
(d)	**M1** for adding two relevant probabilities each less than 0.05

Question Number	Scheme	Marks
6.	Let X = the number of seeds that germinate	
	Let Y = the number of seeds that don't germinate. $x_{\text{obs}} = 66,\ y_{\text{obs}} = 9$	
	$H_0 : p = 0.96$, $H_1 : p < 0.96$ **or** $H_0 : p = 0.04$, $H_1 : p > 0.04$ **or** $H_0 : \lambda = 3$, $H_1 : \lambda > 3$	B1 B1
	{ $Y \sim \text{Bin}(75, 0.04)$ approximates to } $Y \sim \text{Po}(3)$	B1
	$P(Y \geqslant 9) = 1 - P(Y \leqslant 8)$ or $P(Y \leqslant 7) = 0.9881 \Rightarrow P(Y \geqslant 8) = 0.0119$ $P(Y \leqslant 8) = 0.9962$	M1
	$= 1 - 0.9962$	
	$= 0.0038$ CR: $Y \geqslant 9$	A1
	$\{0.0038 < 0.01\}$	
	Reject H_0 or significant or 9 lies in the CR	dM1
	Either • There is evidence that the <u>producer</u> has <u>overstated</u> the <u>probability/percentage/proportion/number</u> of bean <u>seeds</u> that <u>germinate</u>. • <u>Producer's claim is not true</u>. • There is evidence that the <u>producer</u> has <u>understated</u> the <u>probability/percentage/proportion/number/</u> of bean <u>seeds</u> that <u>don't germinate</u>.	A1 cso
		[7]
		7
	Notes	
	1st B1 for $H_0 : p = 0.96$ or $H_0 : p = 0.04$ or $H_0 : / = 3$ **2nd B1** for $H_0 : p = 0.96$ and $H_1 : p < 0.96$ or $H_0 : p = 0.04$ and $H_1 : p > 0.04$ or $H_0 : / = 3$ and $H_1 : / > 3$ **3rd B1** Po(3) seen or implied **1st M1** for writing or using $1 - P(Y \leqslant 8)$ **or** giving $P(Y \leqslant 7) = 0.9881$ or $P(Y \geqslant 8) = 0.0119$ for a CR method (may be implied by probability = 0.0038 or correct CR) **1st A1** for 0.0038 or CR: $Y \geqslant 9$ **2nd M1** Dependent on the 1st M1. For a correct statement i.e. significant/reject H_0/9 is in CR Follow through their probability/CR and their H_1 May be implied by a correct contextual statement. Ignore comparison of probability with the significance level. Do not allow non-contextual conflicting statements. **2nd A1cso** fully correct solution and correct contextual statement	
	B1 B1 Correct hypotheses (same mark scheme as above) **B0** N(72, 2.88) **M1** $\dfrac{\pm(66.5 - 72)}{\sqrt{2.88}} (= \pm 3.24)$ **A0** awrt 0.0006 **dM1A0cso** (same mark scheme as above)	

Question Number	Scheme	Marks
7.		
(a)	 Correct shape with correct curvature and straight line with negative gradient. Must start and end on the x-axis.	B1
	2, 6 and 0.4 labelled in the correct place	B1
		[2]
(b)	{Mode = } 2 <u>**2**</u>	B1
		[1]
(c)	$\{\mathrm{P}(X>2)=\}\ \int_2^6 \frac{1}{10}(6-x)\mathrm{d}x$ **or** $\frac{1}{2}(6-2)(0.4)$ **or** $1-\int_0^2 \frac{1}{20}x^3\mathrm{d}x$	M1
	$=0.8$ <u>**0.8**</u>	A1* **cso**
		[2]
(d)	$\frac{1}{80}x^4,\ 0\le x\le 2$	B1
	$\int_0^2 \frac{1}{20}t^3\mathrm{d}t+\int_2^x \frac{1}{10}(6-t)\mathrm{d}t=0.2+\frac{1}{10}\left[6t-\frac{1}{2}t^2\right]_2^x$ **or** $\int \frac{1}{10}(6-x)\mathrm{d}x=\frac{1}{10}(6x-\frac{1}{2}x^2)+c$ or $-\frac{1}{20}(6-x)^2+d$ with F(2) = 0.2 or F(6) =1	M1
	$\mathrm{F}(x)=\begin{cases}0 & x<0\\ \frac{1}{80}x^4 & 0\le x\le 2\\ \frac{1}{10}(6x-\frac{1}{2}x^2-8)\text{o.e.} & 2<x<6\\ 1 & x>6\end{cases}$ Condone $\le$ for $<$ (etc.) throughout part (d) and vice versa	A1 B1
		[4]
(e)	$\left\{\mathrm{P}(X<a\mid X>2)=\frac{5}{8}\Rightarrow \mathrm{F}(a)=\right\}\ \frac{5}{8}(0.8)+0.2;\ =0.7$ <u>**0.7**</u>	M1A1
		[2]
(f)	$\frac{1}{10}\left(6a-\frac{1}{2}a^2-8\right)=\frac{7}{10}$ **or** $\frac{1}{2}(6-a)\times\frac{1}{10}(6-a)=0.3$	M1
	$\left\{a^2-12a+30=0\Rightarrow\right\}\ a=\frac{12\pm\sqrt{12^2-4(1)(30)}}{2}$	dM1
	$\left\{a=3.5505102...\Rightarrow\right\}\ a=3.55\,(3\,\text{sf})$ awrt <u>**3.55**</u> only	A1
		[3]
		14

	Notes
(c)	**M1** correct expression for $\mathrm{P}(X>2)$ **A1cso** correct solution with no incorrect working seen
(d)	**1st B1** second line of F(x) with correct limits **M1** for a complete method to find F(x) for $2<x<6$ **either** attempt to integrate (at least one $t^n\to t^{n+1}$) both parts of f(t) with correct limits **or** with + c **and** uses F(2) = 0.2 or F(6) =1 **A1** third line of F(x) with correct limits **2nd B1** first and last line of F(x) with correct limits
(e)	**M1** for $\frac{1}{2}$ + their F(2) allow $\frac{5}{8}$(their (c)) + their F(2)
(f)	**1st M1** setting the 3rd line of their F(x) equal to their answer to part (e) **or** area of a triangle **2nd M1** dependent on 1st M1 for solving a 3 term quadratic [See notes in the marking guidance]