edexcel

Mark Scheme (Results)

October 2016

Pearson Edexcel International A-Level 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.

- 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.

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.

IAL Statistics 2 (WST02) – October 2016

Question Number	Scheme	Marks
1. (a)	H_0: $p = 0.05$ H_1: $p > 0.05$	**B1**
	$X \sim B(30, 0.05)$	**B1**
	$P(X \geq 4) = 1 - P(X \leq 3)$ or $P(X \leq 3) = 0.9392$	**M1**
	$= 1 - 0.9392$ $P(X \geq 4) = 0.0608$	
	$= 0.0608$ CR $X \geq 4$	**A1**
	Reject H_0 or Significant or 4 lies in the Critical region.	**dM1**
	The claim is supported/true **or** there is evidence that percentage/%/number/rate of customers who have had a mobile phone stolen is more than 5%.	**A1cso**
		(6)
(b)	$Y \sim B(90, 0.05) \rightarrow Po(4.5)$	**M1 A1**
	$P(Y \leq 6) = 0.8311$ $P(Y \geq 7) = 0.1689 > 0.10$	
	$P(Y \leq 7) = 0.9134$ $P(Y \geq 8) = 0.0866 < 0.10$	**dM1**
	CR: $Y \geq 8$	**A1**
		(4)
		[10 marks]

	Notes
(a)	1st B1 both hypotheses correct (must use p or π) 2nd B1 using B(30, 0.05) (may be implied) 1st M1 for writing or using 1– $P(X \leq 3)$ or giving $P(X \leq 3) = 0.9392$ for CR method 1st A1 for 0.0608 or CR $X \geq 4$ 2nd dM1 dependent on 1st M1 for correct statement (i.e. Reject H_0/Significant/4 lies in the Critical region) (may be implied by a correct contextual statement). Do not allow contradictory statements e.g. 'significant, accept H_0' 2nd A1cso for a correct contextual conclusion and no errors seen. [Two tailed test could score B0B1M1A1dM1 (if comparing p-value with 0.05 and accepting H_0)A0]
(b)	1st M1 writing or using a Poisson approximation 1st A1 for 4.5 2nd dM1 dependent on 1st M1for using Po('4.5') to find a relevant probability for determining the CR ($P(Y \leq 6) = 0.8311$, $P(Y \geq 7) = 0.1689$, $P(Y \leq 7) = 0.9134$, $P(Y \geq 8) = 0.0866$) 2nd A1 for $Y \geq 8$ (allow any letter for Y).

Question Number	Scheme	Marks
2. (a)	F(8) = 0 or F(12) = 1 or using $k = -432$ to verify F(8) = 0 or F(12) = 1	**M1**
	$\frac{1}{96}(74(8)-\frac{5}{2}(8^2)+k)=0$ $\quad$ $\mathrm{F}(8)=\frac{1}{96}(74(8)-\frac{5}{2}(8^2)-432)$	
	$432+k=0$ $\quad$ $=0$	**A1cso**
	$k=-432$ $\quad$ $\therefore k=-432$	**(2)**
(b)	$\mathrm{f}(t)=\dfrac{\mathrm{d}}{\mathrm{d}t}\mathrm{F}(t)$	**M1**
	$[\mathrm{f}(t)=]\begin{cases}\frac{1}{96}(74-5t) & 8\le t\le 12\\ 0 & \text{otherwise}\end{cases}$	**A1**
		(2)
(c)	8	**B1**
		(1)
(d)	$\mathrm{F}(m)=0.5$ or $\int_8^m \frac{1}{96}(74-5t)\mathrm{d}t=0.5$ or $\frac{1}{2}\times(m-8)\frac{1}{96}(34+(74-5m))=0.5$ oe	**M1**
	$5m^2-148m+960=0$ $\rightarrow$ $m=\dfrac{148\pm\sqrt{148^2-4(5)(960)}}{10}$	**dM1**
	$m = 9.6$	**A1**
		(3)
(e)	$\mathrm{F}(9)$ or $\int_8^9 \frac{1}{96}(74-5t)\mathrm{d}t=\dfrac{21}{64}$ $\quad$ $\underline{\frac{21}{64}}$ or awrt **0.328**	**M1 A1**
		(2)
(f)	F(11) – 'F(9)' or $\int_9^{11} \frac{1}{96}(74-5t)\mathrm{d}t=\dfrac{1}{2}$	**M1, A1ft**
	$[\mathrm{P}(T<11\mid T>9)=]\dfrac{\mathrm{P}(9<T<11)}{\mathrm{P}(T>9)}=\dfrac{\mathrm{F}(11)-'\mathrm{F}(9)'}{1-'\mathrm{F}(9)'}$	**M1**
	$=\dfrac{\frac{1}{2}}{1-'\frac{21}{64}'}=\dfrac{32}{43}$ $\quad$ $\underline{\frac{32}{43}}$ or awrt **0.744**	**A1**
		(4)
		[14 marks]

	Notes
(a)	M1 writing or using F(8)=0 or F(12) =1
	A1cso correct solution with at least one intermediate line of working.
(b)	M1 attempting to differentiate F(t) (at least one $t^n \rightarrow t^{n-1}$)
	A1 for both lines of f(t) with correct limits
(d)	1st M1 use of F(m) = 0.5 or correct integral = 0.5
	2nd M1 arranging to form a quadratic equation and attempt to solve (dependent on 1st M1)
	A1 for 9.6 only (must reject other root (m = 20) if stated)
(e)	M1 writing or using F(9) or correct integral
(f)	1st M1 F(11) – F(9) or correct integral with limits 9 and 11
	1st A1ft 0.5 allow follow through F(11) – their answer to (e)
	2nd M1 attempting correct ratio of probabilities (ft their values- but must have num<denom)
Alt	$1-\dfrac{\mathrm{P}(T>11)}{\mathrm{P}(T>9)}$ can score M1A1 when 1 – F(11) or $\int_{11}^{12}\frac{1}{96}(74-5t)\mathrm{d}t=\frac{11}{64}$ and M1A1 for $1-\dfrac{\frac{11}{64}}{1-\frac{21}{64}}=\dfrac{32}{43}$

Question Number	Scheme	Marks
3. (a)	$X \sim B(20,0.4)$	**B1** **(1)**
(b)	$P(4 \leq X < 9) = P(X \leq 8) - P(X \leq 3) = 0.5796$ awrt **0.58(0)**	**M1 A1** **(2)**
(c)	$7X - 3(20 - X) > 0$ $X > 6$ $1 - P(X \leq 6) = 1 - 0.2500 = 0.7500$ awrt **0.75(0)**	**M1** **A1** **M1 A1** **(4)**
(d)	$\text{Var}(X) = 20 \times 0.4 \times 0.6$ [= 4.8] $\text{Var}(7X - 3(20 - X)) = \text{Var}(10X - 60)$ $10^2\text{Var}(X) = 480$	**M1** **M1 A1** **(3)**
		[10 marks]

(a) B1 B(inomial), 20 and 0.4 all required in part (a)

(b) M1 for writing or using $P(X \leq 8) - P(X \leq 3)$ (may be implied by 0.5796 – 0.0160)

(c) 1st M1 using $7X - 3(20 - X)$ and comparing with 0
This may be seen in a table

x	$7x - 3(20 - x)$
5	-10
6	0
7	10

1st A1 $X > 6$
2nd M1 $1 - P(X \leq$ '6') (must be consistent with their '$X > 6$')

(d) 1st M1 use of $\text{Var}(X) = np(1 - p)$ with $p = 0.4$ (or ft their p from part (a))
2nd M1 use of $10^2\text{Var}(X)$

ALT:
1st M1 $\text{Var}(10X - 60) = E(10X - 60)^2 - [E(10X - 60)]^2$
2nd M1 $\text{Var}(10X - 60) = 880 - 400$

Question Number	Scheme	Marks
4. (a)(i)	$\frac{5\times k}{2}+(10.5-5)\times k=1$ $\quad\int_0^5 (mx)\mathrm{d}x+\int_5^{10.5} k\mathrm{d}x=1$ and $5m=k$ $8k=1$ or $\quad\left[\frac{mx^2}{2}\right]_0^5+\left[(5m)x\right]_5^{10.5}=1$ $40m=1$	**M1**
	$k=\frac{1}{8}$*	**A1cso**
(a)(ii)	$m=\frac{1}{40}$	**B1**
		(3)
(b)	$\mathrm{E}(X)=\int_{[0]}^{[5]}(\text{'}\frac{1}{40}\text{'}x^2)\mathrm{d}x+\int_{[5]}^{[10.5]}\frac{1}{8}x\mathrm{d}x$	**M1**
	$\left[\text{'}\frac{1}{40}\text{'}\left(\frac{x^3}{3}\right)\right]_0^5+\left[\frac{1}{8}\left(\frac{x^2}{2}\right)\right]_5^{10.5}=\frac{1223}{192}$ awrt **6.37**	**A1ft A1**
		(3)
(c)	LQ: Using areas $\frac{x\times\text{'}\frac{1}{40}\text{'}x}{2}=0.25$ or $\int_0^{lq}\text{'}\frac{1}{40}\text{'}x\mathrm{d}x=0.25$	**M1**
	UQ: Using areas $\frac{5\times\frac{1}{8}}{2}+(uq-5)\times\frac{1}{8}=0.75$ or $\int_0^5\text{'}\frac{1}{40}\text{'}x\mathrm{d}x+\int_5^{uq}\frac{1}{8}\mathrm{d}x=0.75$	**M1**
	or $(10.5-uq)\times\frac{1}{8}=0.25$ or $\int_{uq}^{10.5}\frac{1}{8}\mathrm{d}x=0.25$	
	either LQ = $\sqrt{20}$ (awrt 4.47) or UQ = 8.5, IQR = $8.5-\sqrt{20}=4.02786\ldots$ awrt **4.03**	**A1** **A1**
		(4)
		[10 marks]

	Notes
(a)	M1 using sum of area of the triangle and area of the rectangle=1 **or** using integration **and** $5m=k$
	A1 for correct solution or for finding *m* and verifying that $k=\frac{1}{8}$
(b)	M1 $xf(x)$ for both parts of pdf **and** attempt to integrate and add (at least one $x^n\to x^{n+1}$)
	1st A1ft correct integration with limits (allow ft on their *m*)
ALT (b)	May see use of moments: $(\triangle)\frac{1}{2}\times 5k\times\frac{10}{3}$ + $(\square)5.5k\times 7.75=\mathrm{E}(X)$ for M1A1
(c)	1st M1 for correct method using areas or integration to find the LQ
	2nd M1 for correct method using areas or integration to find the UQ
	1st A1 for either LQ = awrt 4.47 **or** UQ = 8.5
	2nd A1 for IQR = awrt 4.03

Question Number	Scheme	Marks
5. (a)	L~U[20,40] or $f(l)=\begin{cases}\frac{1}{20} & 20\le l\le 40\\ 0 & \text{otherwise}\end{cases}$	**B1 B1** **(2)**
(b)	$\text{P}(27.5 < L < 28.5) = \dfrac{28.5-27.5}{40-20}=\dfrac{1}{20}$	**M1 A1** **(2)**
(c)	$\left(\dfrac{L}{4}\right)^2 < 64 = \left(\dfrac{L}{4}\right) < 8$	**M1**
	$\text{P}(L<32)=\dfrac{32-20}{40-20}=0.6$	**M1 A1oe** **(3)**
(d)	$\left(\dfrac{L}{4}\right)^2-\left(\dfrac{40-L}{4}\right)^2>81$	**M1**
	$\left(\dfrac{-1600+80L}{16}\right)>81$	
	$L>36.2$	**A1oe**
	$\text{P}(L>36.2)=\dfrac{40-36.2}{40-20}=0.19$	**M1 A1oe** **(4)** **[11 marks]**

	Notes
(a)	1st B1 for Uniform or rectangular or f(l) = $\dfrac{1}{20}$ 2nd B1 for [20, 40] or correct pdf fully specified
(b)	M1 for finding P(27.5 < L < 28.5) from their uniform distribution
(c)	1st M1 for a correct expression for the area and comparison with 64 (allow equation or inequality) (may be implied by L < 32 or L = 32) 2nd M1 using $\text{P}(L<'32')$ with their uniform distribution
(d)	1st M1 a correct expression to find the difference between the two areas and comparison with 81 (allow equation or inequality) (may be implied) 1st A1 for 36.2 oe 2nd M1 using $\text{P}(L>'36.2')$ with their uniform distribution

Question Number	Scheme	Marks
6. (a)	Po (λ)	**M1**
	$e^{-\lambda} + \lambda e^{-\lambda}$	**A1oe**
		(2)
(b)	Po ($\frac{\lambda}{2}$)	**M1**
	$\frac{\lambda}{2} e^{-\lambda/2}$	**A1oe**
		(2)
(c)(i)	Mean is large, so a normal approximation is used.	**B1**
(ii)	$Y \sim N(10\lambda, 10\lambda)$	**M1**
	$P(Y < 15) = P\left(Z < \frac{14.5 - 10\lambda}{\sqrt{10\lambda}}\right)$	
	$\frac{14.5 - 10\lambda}{\sqrt{10\lambda}} = -2.1(0)$	**M1 M1 A1**
	$10\lambda - 2.10\sqrt{10\lambda} - 14.5 = 0 \rightarrow \sqrt{10\lambda} = \frac{2.10 \pm \sqrt{2.10^2 - 4(-14.5)}}{2} = 5$	**dM1 A1**
	or $100\lambda^2 - 334.1\lambda + 210.25 = 0 \rightarrow \lambda = \frac{334.1 \pm \sqrt{334.1^2 - 4(100)(210.25)}}{200} = 2.5 \text{ or } 0.841$	
	$\lambda = 2.5$	**A1**
		(8)
		[12 marks]

	Notes
(a)	M1 writing or using Po (λ)
	A1oe for any correct equivalent expression (need not be simplified)
(b)	M1 writing or using Po($\lambda/2$)
(c)(i)	Allow 'since mean/10 λ is large' [Note: λ is large on its own is B0]
(ii)	1st M1 for mean = variance [=10 λ]
	2nd M1 continuity correction 15.5 or 14.5
	3rd M1 standardising with 14.5, 15 or 15.5 and s.d.= $\sqrt{\text{mean}}$ **and** equating to a *z*-value, $\lvert z \rvert > 1$
	1st A1 $\frac{14.5 - \mu}{\sqrt{\mu}}$ = awrt –2.10 (correct standardisation with compatible signs)
	4th dM1 attempt at solving their 3TQ $\frac{-b \pm \sqrt{+ve}}{2a}$ dependent on 3rd M1 (may be implied by one correct answer for $\sqrt{\mu}$, μ or $\sqrt{\lambda}$)
	2nd A1 dep on 1st A1 $\sqrt{\mu}$ = awrt 5.00 or μ = awrt 25.0 or $\sqrt{\lambda} = \frac{5}{\sqrt{10}}$ = awrt 1.58
	3rd A1 dep on 1st A1 λ = awrt 2.5(0) (must reject other solutions if found)

Question Number	Scheme	Marks
7. (a)	Possible values of S = 2, 3, 4, 5, 6	**B1**
	$P(S=2) = \frac{5}{8}\times\frac{5}{8}$ $\quad P(S=6) = \frac{1}{8}\times\frac{1}{8}$	**M1 A1**
	$P(S=3) = 2\times\frac{5}{8}\times\frac{2}{8}$ $\quad P(S=4) = \frac{2}{8}\times\frac{2}{8} + 2\times\frac{5}{8}\times\frac{1}{8}$ $\quad P(S=5) = 2\times\frac{1}{8}\times\frac{2}{8}$	**M1**
	s | 2 | 3 | 4 | 5 | 6 $P(S=s)$ | $\frac{25}{64}$ [0.390625] | $\frac{20}{64}\left(=\frac{5}{16}\right)$ [0.3125] | $\frac{14}{64}\left(=\frac{7}{32}\right)$ [0.21875] | $\frac{4}{64}\left(=\frac{1}{16}\right)$ [0.0625] | $\frac{1}{64}$ [0.015625]	**A1** **(5)**
(b)	Let X = number of scoops ordered by n customers	
	$P(X = n) = \left(\frac{5}{8}\right)^n$	
	$P(X > n) = 1 - \left(\frac{5}{8}\right)^n$	**M1**
	$1 - \left(\frac{5}{8}\right)^n > 0.99$	
	$\left(\frac{5}{8}\right)^n < 0.01$	**dM1**
	$n > 9.798\ldots$	
	$n = 10$	**A1cao** **(3)** **[8 marks]**

	Notes
(a)	B1 for the 5 values of S
	1st M1 for p^2 for P(S=2) or P(S=6)
	1st A1 $\frac{25}{64}$ **and** $\frac{1}{64}$ (allow awrt 0.391 and awrt 0.0156)
	2nd M1 for $2pq$ for P(S=3) or P(S=5) or $p^2 + 2pq$ or P(S=4)
	2nd A1 for the complete probability distribution (allow awrt 3sf)
	[Note: If the 5 values of S are not found, then can score B0M1A1M1A0]
(b)	1st M1 $1 - p^n > 0.99$ (allow equation) or equivalent (e.g. $p^n < 0.01$)
	2nd dM1 dependent on 1st M1 for correct use of a valid method to solve to $n > k$ (allow equation)
	A1 for 10 cao

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