



Pearson

Mark Scheme (Results)

Summer 2017

Pearson Edexcel International A 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 GCE 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)
 - **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.

June 2017
WST02 STATISTICS 2
Mark Scheme

Question	Scheme	Marks
1.(a)	$X \sim \text{Po}(\frac{1}{4})$ $P(X=0) = e^{-\frac{1}{4}} = 0.778800\dots$	B1 B1 (2) awrt <u>0.779</u>
(b)	$[(P(X \geq 1))^3] = (1 - '0.7788')^3 = 0.010823\dots$	M1 A1 (2) awrt <u>0.0108</u>
(c)	$Y \sim B(7, 0.7788\dots)$ $P(Y=5) = {}^7C_5 (0.7788)^5 (1 - 0.7788)^2 = 0.294386\dots$	B1ft M1 A1 (3) awrt <u>0.294</u>
(d)	$H_0: \mu = 8 \text{ or } \lambda = 0.25$ $H_1: \mu < 8 \text{ or } \lambda < 0.25$	B1 (1)
(e)	$W \sim \text{Po}(8)$ $P(W \leq 3) = 0.0424 (< 0.05)$ $P(W \leq 4) = 0.0996 (> 0.05)$ Largest possible value of f is 3	B1 M1 A1 (3) Total 11
Notes		
(a)	1 st B1 for writing or using $\text{Po}(\frac{1}{4})$. May be implied by a correct answer or by awrt 0.78	
(b)	M1 for $(1 - 0.779)^3$ <u>or</u> $(1 - \text{'their (a)'})^3$	
(c)	B1ft for writing or using $B(7, \text{'their a'})$. May be implied by M1 scored. M1 for a correct binomial expression for $P(Y=5)$ (ft their value of p). Allow $\binom{7}{2}$ etc or 21 May be implied by the correct answer but if $p \neq 0.779$ or better we must see expression	
ALT	They may use $W \sim B(7, "1 - \text{their (a)}")$ for B1ft then $P(W=2)$ for the M1	
(d)	B1 for both hypotheses correct. Must use λ or μ for either 8 or 0.25 [Use of \leq is B0] If (d) is blank but correct hypotheses are seen in (e) can award retrospectively BUT if hypotheses are given in (d) <u>and</u> (e) award this mark for answer in (d).	
(e)	B1 for writing $\text{Po}(8)$ can be awarded if seen in (d) (may be implied e.g. by scoring M1) M1 for using $\text{Po}(8)$ to find a lower-tail critical region Need to see one of the given probability statements <u>or</u> implied by $\text{Po}(8)$ <u>and</u> $f=3$ seen. A1 for $[f]=3$ but allow $f \leq 3$ Correct answer only scores 3/3	

Question	Scheme	Marks
2. (a)(i)	$X \sim B(6, 0.25)$	B1
(ii)	Prizes are randomly placed in packets. Each packet has a 25% chance of containing a prize Each packet contains a prize independently of others	B1 (2)
(b)	$P(X = 1) = \binom{6}{1} (0.25)(1 - 0.25)^5 [= 0.355957\dots] \text{ or } 0.5339 - 0.1780 [= 0.3559]$ $P(\text{only 1 box contains exactly 1 prize}) = 2P(X = 1)(1 - P(X = 1)) =$ answer in the range 0.458~0.459 (inc)	M1 M1 A1 (3)
(c)	$P(X \geq 2) = 1 - P(X \leq 1) = 1 - 0.5339 = 0.4661$ awrt 0.466	M1 A1 (2)
(d)	$Y \sim B(80, '0.4661') \rightarrow N(\text{awrt } 37.3, \text{awrt } 19.9)$ [Calc : 37.285..., 19.9078...] $P(Y \leq 30) \approx P\left(Z < \frac{30.5 - '37.3'}{\sqrt{19.9}}\right)$ $P(Z < -1.52) = 1 - 0.9357 = 0.0643$ (calc: 0.064165....) awrt 0.064	B1ft M1 dM1A1ft A1 (5)
Notes		Total 12
(a)(i)	B1 for a completely specified distribution. Condone B(6,25%) must be in (a)(i)	
(ii)	B1 for a contextualised reason involving randomness, independence or constant probability Must mention "prize" and "packet" and for constant prob "0.25" in correct statement.	
(b)	1 st M1 for a correct expression for $P(X = 1)$ may use $P(X \leq 1) - P(X = 0)$ from tables with $X \sim B(6, 0.25)$ (May be implied by sight of awrt 0.356 or answer in range) 2 nd M1 for writing or using $2P(X = 1)(1 - P(X = 1))$ NB M0M1A0 is possible Allow just $2P(X = 1)(1 - P(X = 1))$ or a numerical expression with any $p = P(X = 1)$ except $p = 0.25$ provided $0 < p < 1$	
(c)	M1 for writing or using $1 - P(X \leq 1)$ A1 for awrt 0.466 (calc: 0.46606445....)	
(d)	1 st B1ft for mean = np and variance = $np(1 - p)$ where $p =$ 'their (c)' ft their $0.466 \neq 0.25$ Any ft values must be correct to at least 3sf 1 st M1 $\pm \left(\frac{29.5 \text{ or } 30 \text{ or } 30.5 - \text{their mean}}{\text{their sd}} \right)$ 2 nd M1 dependent on 1 st M1 for using a continuity correction 30 ± 0.5 1 st A1ft for (+) correct standardized expression (ft their μ and σ) or $z = \text{awrt } \pm 1.52$ 2 nd A1 awrt 0.064 [Use of $p = 0.25$ giving $N(20, 15)$ can score B0M1M1A1A0 i.e. max 3/5]	
NB	Use of binomial (leads to 0.063398... or 0.063477...) but scores 0 marks.	

Question	Scheme		Marks	
<p>3. (a)</p>	<p>Using area of triangle: $P(X > 4) = \frac{(6-4) \times f(4)}{2}$ $= \frac{1}{2} \text{ [so median of } X \text{ is 4]}$</p>	<p>Solve: $\frac{(6-4)\left(\frac{3}{2} - \frac{1}{4}x\right)}{2} = \frac{1}{2}x$ $= 4$ [so median of X is 4]</p>	<p>Using integration: $P(X > 4)$ $= \int_4^6 \left(\frac{3}{2} - \frac{1}{4}x\right) dx = \left[\frac{3}{2}x - \frac{1}{8}x^2\right]_4^6$ $= \frac{1}{2} \text{ [so median of } X \text{ is 4]}$</p>	<p>M1 A1cso (2)</p>
<p>(b)</p>	<p>Area of triangle from $1 < x < 4 = 0.5$ $\frac{(4-1) \times (4a+b)}{2} = 0.5 \rightarrow 12a + 3b = 1$ $f(1) = 0 \rightarrow a + b = 0$ Solving simultaneously: $12a - 3a = 1$ $a = \frac{1}{9} \quad b = -\frac{1}{9}$</p>	<p>$\int_1^4 (ax + b) dx = 0.5$ $\left(\frac{16a}{2} + 4b\right) - \left(\frac{a}{2} + b\right) = 0.5 \rightarrow 15a + 6b = 1$ $f(1) = 0 \rightarrow a + b = 0$ Solving simultaneously: $15a - 6a = 1$ $a = \frac{1}{9} \quad b = -\frac{1}{9}$</p>		<p>M1 M1 dM1 A1 A1 (5)</p>
<p>(c)</p>	<p>$\int_1^x \left(\frac{1}{9}t - \frac{1}{9}\right) dt$ $0.5 + \int_4^x \left(\frac{3}{2} - \frac{1}{4}t\right) dt$ $F(x) = \begin{cases} 0 & x < 1 \\ \frac{1}{18}x^2 - \frac{1}{9}x + \frac{1}{18} & 1 \leq x < 4 \\ \frac{3}{2}x - \frac{1}{8}x^2 - \frac{7}{2} & 4 \leq x \leq 6 \\ 1 & x > 6 \end{cases}$</p>	<p>or $\int \left(\frac{1}{9}x - \frac{1}{9}\right) dx$ with $+c$ and $F(1) = 0$ or $F(4) = 0.5$ or $\int \left(\frac{3}{2} - \frac{1}{4}x\right) dx$ with $+c$ and $F(6) = 1$ or $F(4) = 0.5$</p>		<p>M1 M1 B1 A1 A1 (5)</p>
Notes				
<p>(a)</p> <p>(b)</p> <p>(c)</p>	<p>M1 for a correct expr' area above 4 using triangle <u>or</u> correct integral & attempt to integrate A1cso for $\frac{1}{2}$ or $x = 4$ with no errors. NB $f(4)=1.5 - 1 = 0.5$ or $1.5 - 0.25x = 0.5$ is M0A0 Allow use of correct $F(x) = 0.5$ provided $F(4) = 0.5$ not used to establish $F(x)$</p> <p>1st M1 for a correct equation in a and b for an area (need not be simplified) 2nd M1 for a correct equation in a and b using $f(1) = 0$ 3rd dM1 dep on at least 1 M1; for solving two linear equations in a and b by eliminating one variable (allow one slip). If one equation is incorrect we must see explicit method to solve. 1st A1 for a and 2nd A1 for b (allow exact equivalents)</p> <p>1st M1 for attempt to integrate $ax + b$ with correct limits or $+c$ and $F(1) = 0$ or $F(4) = 0.5$ 2nd M1 for attempt to integrate $\frac{3}{2} - \frac{1}{4}x$ with correct limits & $+0.5$ or $+c$ and $F(6) = 1$ or $F(4) = 0.5$ For the 2nd M1 allow $\int_1^4 (their\ ax + b) dx$ or $F(4)$ based on their cdf for $[1, 4)$ instead of $+0.5$</p> <p>B1 for 1st and 4th line correct 1st A1 correct 2nd line with limits NB $\frac{1}{18}(x-1)^2$ 2nd A1 correct 3rd line with limits NB $1 - \frac{1}{8}(x-6)^2$</p>			<div style="border: 1px solid black; padding: 5px; width: fit-content; margin-left: auto;"> Allow $<$ or \leq anywhere for the last 3 marks </div>

Question	Scheme	Marks
4. (a)(i) (ii)	mean = $np = 3.5$ standard deviation = $\sqrt{700 \times \frac{1}{200} (1 - \frac{1}{200})} = 1.86614...$ awrt <u>1.866</u>	B1 M1 A1 (3)
(b)(i) (ii)	$H_0: p = \frac{1}{200}$ $H_1: p > \frac{1}{200}$ $X \sim B(500, \frac{1}{200}) \rightarrow \text{Po}(2.5)$ $P(X \geq 5) = 1 - P(X \leq 4) = 1 - 0.8912 = 0.1088$ [0.1088 > 0.05] therefore do not reject H_0 , not significant, 5 does not lie in CR The doctor's <u>claim</u> is <u>not supported</u> . or Past <u>records</u> are <u>not out of date/reliable</u> or <u>Number/ Proportion / Probability</u> of people/ with <u>allergy</u> is <u>not higher</u> .	B1 B1 M1 A1 M1 A1 cso (6)
(c)	$Y \sim B(n, 0.30)$ $P(Y = 0) = (0.70)^n < 0.005$ $n > 14.85$ $n = 15$ $P(Y \geq w) < 0.005$ $P(Y \leq 8) = 0.9848$ or $P(Y \geq 9) = 0.0152$ [> 0.005] $P(Y \leq 9) = 0.9963$ or $P(Y \geq 10) = 0.0037$ [< 0.005]	M1 A1cao M1 A1 (4)
<u>w = 10</u>		Total 13
Notes		
(a)(ii)	M1 for a correct expression for standard deviation including root NB Assuming Poisson will get $\sqrt{3.5} = 1.87082...$ but scores M0A0 [Ans only 2/2]	
(b)(i) (ii)	B1 H_0 and H_1 correct with p or π (may be seen in (ii)) [Use of λ or $\mu = 2.5$ for (i) is B0] B1 for writing or using Po(2.5) 1 st M1 for $1 - P(X \leq 4)$ and use with bin or Poisson or for CR $P(X \geq 6) = 0.042$ [< 0.05] 1 st A1 for awrt 0.109 or for CR $X \geq 6$ 2 nd M1 for a non-contradictory statement which follows from their probability/CR 2 nd A1cso correct contextual statement and fully correct solution with all other marks scored in (b) (ii)	
NB	Use of Binomial leading to 0.1083 in (b) can score B1B0M1A0M1A0 Use of Normal [may get 0.103 (Po) or 0.102 (bin)] in (b) can score B1B0M0A0M1A0	
(c)	1 st M1 for a correct expression for $P(Y = 0)$ and comparison with 0.005 [allow inequality or equation]. Use of tables alone is M0 1 st A1 for $n = 15$ cao [Answer only is M0A0 unless we see the 0.7^n compared to 0.005] 2 nd M1 for using B("15", 0.30) to try and find an upper tail, need sight of <u>one</u> of given probs ft If 1 st M1 scored can ft their n but need sight of probability expression and probability one of which must be a correct ft and must be just above or just below 0.005 (o.e.) 2 nd A1 for $w = 10$ [but $w \geq 10$ is A0] Allow $Y \geq 10$ or $Y > 9$ [Correct answer only scores M0A0M1A1]	

Question	Scheme	Marks
5. (a)	$P(\text{customer waits} > 4 \text{ minutes}) = 1 - F(4) = 1 - [0.3(4) - 0.004(4^3)] =$ $\frac{7}{125} \quad \text{or} \quad \underline{\underline{0.056}}$	M1 A1 (2)
(b)	$P(\text{customer waits} > 4 \text{ minutes} \mid \text{customer waits} > 2 \text{ minutes}) =$ $\frac{P(T > 4)}{P(T > 2)} = \frac{"0.056"}{1 - F(2)} = \frac{"0.056"}{1 - [0.3(2) - 0.004(2^3)]} = \frac{"0.056"}{0.432} =$ $\frac{7}{54} \quad \text{or awrt} \underline{\underline{0.130}}$	M1,A1ft A1 (3)
(c)	$F(2.7) = 0.73(1268\dots) \quad \text{or} \quad F(2.7) - 0.75 = -0.02\dots$ $F(2.8) = 0.752(192\dots) \quad \text{or} \quad F(2.8) - 0.75 = (+) 0.002\dots$ <p>$F(2.7) < 0.75 < F(2.8)$ therefore $2.7 < \text{upper quartile} < 2.8$</p>	M1 A1cso (2)
(d)	$f(t) = 0.3 - 0.012t^2$ $E(T) = \int_0^5 t(0.3 - 0.012t^2) dt = \left[\frac{0.3t^2}{2} - \frac{0.012t^4}{4} \right]_0^5 = \frac{0.3 \times 5^2}{2} - \frac{0.012 \times 5^4}{4}$ $= \frac{15}{8} \quad \text{or} \quad 1.875$	M1 M1, A1 A1 (4)
Notes		Total 11
(a)	M1 for writing or using $1 - F(4)$ [Just writing $F(4) = 0.944$ alone is M0]	
(b)	M1 for a correct ratio expression $\frac{P(T > 4)}{P(T > 2)}$ or $\frac{"(a)"}{P(T > 2)}$ or better. Ignore e.g. $P(T > 2 \mid T > 4)$ Allow other letters for T . If <u>only</u> numerical values are used, must have num < denom. 1 st A1ft for a correct ratio expression with 'their (a)' on numerator and correct numerical expression or 0.43 or better on denominator.	
(c)	M1 for attempting to find $F(2.7)$ and $F(2.8)$ A1cso for both $F(2.7) = \text{awrt } 0.73 < 0.75 < F(2.8) = \text{awrt } 0.752$ and correct conclusion. May use $F(x) - 0.75$ and look for a change of sign. There must be sight of 0.75	
ALT	Using calculator: M1 for $0.3t - 0.004t^3 = 0.75$ leading to $t = \text{awrt } 2.79 (2.78937\dots)$ A1 for correct conclusion (must reject other roots i.e. 6.9218... and -9.7112 if found) Conclusion must clearly state that Q_3 is between 2.7 and 2.8. Penalise false statements.	
(d)	1 st M1 for differentiating $F(t)$ to find $f(t)$ [Just 2 terms with at least 1 correct] 2 nd M1 for attempting to integrate $t \times \text{their } f(t)$ ignore limits [at least one $t^n \rightarrow t^{n+1}$] 1 st A1 for correct integration of correct $f(t)$ & use of limits (must see <u>some</u> correct use of 5) This mark may be implied by a correct answer. 2 nd A1 $\frac{15}{8}$ or 1.875 (condone 1.88) [Correct answer only of $\frac{15}{8}$ or 1.875 scores 4/4]	
Special Case	Use of $E(T) = 5 - \int_0^5 F(t) dt$ can score 4 out of 4 if fully correct.	

Question	Scheme	Marks												
6. (a)	(3, 3, 3)	B1B1												
	(3, 3, 4) × 3 [(3, 4, 3), (4, 3, 3)]													
	(3, 4, 4) × 3 [(4, 3, 4), (4, 4, 3)]													
	(4, 4, 4)	(2)												
(b)	$P(M = 3) = (0.5)^3 = 0.125$	B1												
	$P(M = 5) = 1 - (0.8)^3$ <u>or</u> $P(M = 5) = 3(0.2)(0.8)^2 + 3(0.2)^2(0.8) + (0.2)^3$ <u>or</u> $P(M = 4) = 3(0.5)^2(0.3) + 3(0.5)(0.3)^2 + (0.3)^3$	M1												
	$P(M = 4) = 1 - [(P(M = 3) + P(M = 5))] \text{ or } P(M = 5) = 1 - [(P(M = 3) + P(M = 4))]$	M1												
	<table border="1" style="width: 100%; text-align: center;"> <thead> <tr> <th>m</th> <th>3</th> <th>4</th> <th>5</th> </tr> </thead> <tbody> <tr> <td>$P(M = m)$</td> <td>0.125</td> <td>0.387</td> <td>0.488</td> </tr> <tr> <td></td> <td>$\left(\frac{1}{8}\right)$</td> <td>$\left(\frac{387}{1000}\right)$</td> <td>$\left(\frac{61}{125}\right)$</td> </tr> </tbody> </table>	m	3	4	5	$P(M = m)$	0.125	0.387	0.488		$\left(\frac{1}{8}\right)$	$\left(\frac{387}{1000}\right)$	$\left(\frac{61}{125}\right)$	A1
m	3	4	5											
$P(M = m)$	0.125	0.387	0.488											
	$\left(\frac{1}{8}\right)$	$\left(\frac{387}{1000}\right)$	$\left(\frac{61}{125}\right)$											
(c)	Mode of <u>$S_1 = 3$</u> and Mode of <u>$M = 5$</u>	B1												
		(4)												
		(1)												
		Total 7												
Notes														
(a)	1 st B1 for at least 4 correct samples listed e.g. (3, 3, 3) and (3, 3, 4) × 3 2 nd B1 for all 8 correct samples listed (with no extra or incorrect ones given)													
(b)	B1 for $P(M = 3) = 0.125$ oe Condone e.g. $X = 3$ and 12.5% 1 st M1 for a correct expression <u>or</u> a correct probability for $P(M = 5)$ or $P(M = 4)$ 2 nd M1 for a correct expression for third probability of 3, 4 or 5 or if B1 or 1 st M1 are scored then award this mark for using the sum of the probs = 1 A1 for both $P(M = 4) = 0.387$ oe and $P(M = 5) = 0.488$ oe													
(c)	B1 for both correct modes with clear S and M labels													

Question	Scheme	Marks	
7.(a)	$E(3 - 2X) = 3 - 2E(X) [= 3 - 2 \left(\frac{a+b}{2} \right)]$ $= \underline{3 - a - b}$	M1 A1 (2)	
(b)	$P(X > \frac{1}{3}b + \frac{2}{3}a) =$ $\frac{b - (\frac{1}{3}b + \frac{2}{3}a)}{b - a}, = \frac{2}{3} \quad \text{or} \quad 1 - \frac{(\frac{1}{3}b + \frac{2}{3}a) - a}{b - a}, = \frac{2}{3}$	M1, A1 (2)	
(c)	$E([3]X^2) = \int_a^b \frac{1}{(b-a)} [3]x^2 dx$ $= \left[\frac{1}{(b-a)} x^3 \right]_a^b = \left(\frac{b^3 - a^3}{3(b-a)} \right)$ $= b^2$	$[\text{Var}(X) = E(X^2) - [E(X)]^2]$ $\frac{(b-a)^2}{12} = E(X^2) - 0^2 \quad \text{or} \quad E(X^2) = \frac{(a+b)^2}{4}$ $E(3X^2) = 3 \left(\frac{(b-a)^2}{12} \right)$ $= b^2$	M1 dM1 A1 (3)
(d)	$\text{Range} = b - a = 18 \quad \text{or} \quad b - -b = 18 \quad \text{or} \quad b = 9$ $\text{Var}(X) = \left[\frac{18^2}{12} \quad \text{or} \quad \frac{9^2}{3} - 0^2 \right] = \underline{27}$	M1 A1 (2)	
Notes			
(a)	M1 for using $3 - 2E(X)$ where $E(X)$ is a linear function of a and b A1 for $3 - a - b$ or $3 - (a + b)$		
(b)	M1 for a correct fraction expression for $P(X > \frac{1}{3}b + \frac{2}{3}a)$ in terms of a and b (need brackets!) A1 for $\frac{2}{3}$		
(c)	1 st M1 for a correct integral for $E(3X^2)$ or $E(X^2)$ (ignore limits) 2 nd dM1 dependent on 1 st M1 for correct integration and correct use of $a = -b$ including in limits. Must be $E(3X^2)$		
ALT	1 st M1 for a correct expression for $E(3X^2)$ or $E(X^2)$ in terms of a and b from substituting into $\text{Var}(X)$ and using $E(X) = 0$ or $\frac{(a+b)}{2}$ 2 nd dM1 dependent on 1 st M1 for $3E(X^2)$ and correct use of $a = -b$		
(d)	M1 for writing or using $(b - a) = 18$ or $b - -b = 18$ or $b = 9$ A1 for 27 [Correct answer only is 2/2]		