



Mark Scheme (Results)

Summer 2014

Pearson Edexcel GCE in Statistics S2R  
(6684/01R)

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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.

## 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.

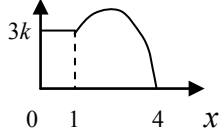
5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.
6. If a candidate makes more than one attempt at any question:
  - If all but one attempt is crossed out, mark the attempt which 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.

Question	Scheme	Marks
1.	$H_0 : p = 0.2$ $H_1 : p < 0.2$ $[X \sim B(40, 0.2)]$ $P(X \leq 3) = 0.0285$ or CR of $X \leq 3$ $[0.0285 < 0.05]$ significant, reject $H_0$ There is evidence to support the supplier's <b>claim</b> or The probability of a <b>ball</b> failing the bounce <b>test</b> is <b>less</b> than <b>0.2</b>	B1 M1A1 M1dep A1cso (5)
<b>Notes</b>		
$1^{\text{st}}$ B1 for both $H_0$ and $H_1$ must use $p$ or $\pi$ $1^{\text{st}}$ M1 for writing or using $B(40, 0.2)$ , may be implied by correct answer $1^{\text{st}}$ A1 awrt 0.0285 or CR of $X \leq 3$ as their final answer $2^{\text{nd}}$ M1 dependent on the previous method mark being awarded. A correct statement (this may be contextual) comparing “their probability” and 0.05 (or comparing 3 with their critical region). Do not allow conflicting statements. $2^{\text{nd}}$ A1cso This is cso so can only be awarded for a fully correct solution. A correct contextualised conclusion ( to include the words underlined in bold)		

Question	Scheme	Marks
<p>2. (a)</p> <p>(b)</p> <p>(c)</p>	<p>(i) <math>S</math> <u>is</u> a statistic, (ii) <math>D</math> is <u>not</u> a statistic, (iii) <math>F</math> <u>is</u> a statistic</p> <p><math>T \sim B(10, 0.4)</math></p> <p><math>P(2' 2' 2)</math> or <math>P(5 5 2, 5 &gt; 5 2, &gt; 5 &gt; 5 2)</math>  <math>= 0.6^2 \times 0.4</math> =  <math>(0.25)^2 (0.4) + 2 \times (0.25)(0.35)(0.4) + (0.35)^2 (0.4)</math>  <math>= 0.144</math></p>	<p>B1, B1, B1 (3) M1A1 (2)</p> <p>M1</p> <p>A1 (2)</p> <p>(7)</p>
<b>Notes</b>		
<p>(a)</p> <p>(b)</p> <p>(c)</p>	<p>B1 for each variable. Accept “yes, no, yes” o.e.</p> <p>M1 for binomial A1 for <math>n = 10</math> and <math>p = 0.4</math> NB If they give 2 options then unless they select the correct one they gain M0A0</p> <p>M1 for identifying the correct possibilities <math>2' 2' 2</math> <u>or</u> <math>5 5 2</math> and <math>5 &gt; 5 2</math> and <math>&gt; 5 5 2</math> and <math>&gt; 5 &gt; 5 2</math> <u>or</u> a correct probability statement. The possibilities must be in the correct order. Condone <math>2 \times (5 &gt; 5 2)</math> or <math>2 \times (&gt; 5 5 2)</math>. Implied a correct answer. A1 for 0.144 or exact equivalent e.g. <math>\frac{18}{125}</math></p>	

Question	Scheme	Marks
3. (a)	$X \sim \text{Po}(9)$	M1A1 (2)
(b)	$P(X > 7) = 1 - P(X \leq 7)$ $= [1 - 0.3239] = 0.6761$	M1 A1 (2)
(c)	<p>[Y = no. of accidents in a month] <math>Y \sim \text{Po}(1.5)</math></p> $P(Y \geq 1) = 1 - P(Y = 0)$ $= [1 - 0.2231] = 0.7769 (= 0.777 \text{ (3dp)})^*$	B1 M1 A1cso (3)
(d)	<p>[A = no. of months with at least one accident] <math>A \sim \text{B}(6, 0.777)</math></p> $P(A = 4) = \binom{6}{4} (0.777)^4 (0.223)^2$ $= 0.2719\dots \quad \text{awrt } \mathbf{0.272}$	M1 M1 A1 (3) <b>(10)</b>
<b>Notes</b>		
(a)	M1 for Poisson (accept Po). Condone P(9) A1 for mean of 9	
(b)	M1 for writing $1 - P(X \leq 7)$ . This may be implied by $1 - 0.3239$ or a correct answer A1 for awrt 0.676	
(c)	B1 Po(1.5) written or used M1 writing or using $1 - P(Y = 0)$ or $1 - P(Y \leq 0)$ or $1 - e^{-\lambda}$ [may not be Y] A1 for at least $(1 - 0.223)$ or better. No need for final comment.* answer given so 0.777 does not imply all three marks	
(d)	1 <sup>st</sup> M1 for identifying binomial with $n = 6$ and $p = 0.777$ or better. Condone use of $p = 0.223$ . May be implied by $(p)^4(1-p)^2$ $p =$ awrt 0.777 or awrt 0.223 2 <sup>nd</sup> M1 Must have ${}^6C_4 (0.777)^4(1-0.777)^2$ A1 for awrt 0.272	



Question	Scheme	Marks
<p>4. (a)</p> <p>(b) Mode = 2</p> <p>(c) Mean &lt; mode, so negative skew</p> <p>(d)</p> <p>(e) Lower Quartile = 1</p> <p>(f) <math>P(1 &lt; X &lt; 2) = P(2 &lt; X &lt; 3)</math> by symmetry</p>	 $3k \times 1 + \int_1^4 (4kx - kx^2) dx = 1$ $3k + \left[ 2kx^2 - \frac{kx^3}{3} \right]_1^4 \{= 1\}$ $3k + \left( 32k - \frac{64k}{3} \right) - \left( 2k - \frac{k}{3} \right) = 1$ $12k = 1 \quad \text{so } k = \frac{1}{12}$ $\text{So } P(X > 3) = 1 - 3k - \frac{22}{36} = \frac{5}{36}$	<p>B1B1B1 (3)</p> <p>B1 (1)</p> <p>B1, dB1 (2)</p> <p>M1, B1</p> <p>M1</p> <p>M1d</p> <p>A1 (5)</p> <p>B1 (1)</p> <p>M1</p> <p>A1 (2)</p> <p><b>(14)</b></p>
<b>Notes</b>		
	<p>(a) 1<sup>st</sup> B1 for horizontal line <math>y = 3k</math> and <math>3k</math> marked on <math>y</math>-axis  2<sup>nd</sup> B1 for correct shape for <math>1 &lt; x &lt; 4</math>, meeting <math>x</math>-axis at <math>(4, 0)</math> and not extending below <math>x</math>-axis. Must be a curve  3<sup>rd</sup> B1 for <math>x = 1</math> marked and graphs meeting at the point <math>(1, 3k)</math></p> <p>(b) B1 for 2</p> <p>(c) 1<sup>st</sup> B1 for a suitable reason which matches their mode. The mode must be a number. Must use mean.  2<sup>nd</sup> dB1 not ft, dependent on 1<sup>st</sup> B1. Correct answer from correct value of Mode.</p> <p>(d) 1<sup>st</sup> M1 for attempting the sum of both areas = 1, ignore limits  B1 for <math>3k</math> seen added to integral  2<sup>nd</sup> M1 For some correct integration, at least one <math>kx^n \rightarrow kx^{n+1}</math>  3<sup>rd</sup> M1d Dependent on 1<sup>st</sup> M1 being awarded. For use of correct limits.  A1 for <math>k = \frac{1}{12}</math></p> <p>(e) B1 for 1</p> <p>(f) M1 for identifying the symmetry. May be implied by <math>P(1 &lt; x &lt; 2) = \frac{11}{36}</math> found by any method  or writing down a correct equation (ft their <math>k</math>). e.g  <math>0.75 - 2 \times \frac{11}{36}</math> or <math>\int_3^4 kx(4-x) dx</math> or <math>1 - 3k - \frac{11}{36} - \int_1^2 4kx - kx^2</math> with their <math>k</math> subst in  A1 for <math>\frac{5}{36}</math> or exact equivalent</p>	

Question	Scheme	Marks
<p><b>5. (a)</b></p> <p><b>(b)</b></p> <p><b>(c)</b></p>	<p><math>H_0 : \lambda = \frac{1}{8}</math> ( or <math>\lambda=5</math> )    <math>H_1 : \lambda \neq \frac{1}{8}</math> ( or <math>\lambda \neq 5</math> )    allow <math>\lambda</math> or <math>\mu</math></p> <p><math>X \sim \text{Po}(5)</math>, <math>P(X \leq 1) = 0.0404</math> or <math>P(X \geq 10) = 0.0318</math> or <math>P(X \geq 9) = 0.0681</math></p> <p>Critical Regions: <math>X \leq 1</math> or <math>X \geq 10</math></p> <p><math>0.0404 + 0.0318 = 0.0722</math> (or 7.22% significance level)</p> <p><math>H_0 : \lambda = \frac{1}{8}</math> ( or <math>\lambda = 25</math> )    <math>H_1 : \lambda &lt; \frac{1}{8}</math> ( or <math>\lambda &lt; 25</math> )    allow <math>\lambda</math> or <math>\mu</math></p> <p>[Y= no. of defects in 200m of wallpaper] <math>Y \sim \text{Po}(25)</math> <math>Y \approx \sim N(25, \sqrt{25^2})</math></p> <p><math>P(Y \leq 19) \approx P\left(Z &lt; \frac{19.5 - 25}{\sqrt{25}}\right)</math>    or <math>\pm \frac{x - 0.5 - 25}{5} = 1.96</math></p> <p><math>= [P(Z &lt; -1.1)] = 0.1357</math> (or 0.13566... from calc)    <math>x = 35.3</math></p> <p>[&gt; 0.05] not significant, there is insufficient evidence to support <b>Thomas' claim.</b></p> <p>Or The <u>number/rate/amount</u> of <u>defects</u> is not <u>decreased/less/reduced</u></p>	<p>B1</p> <p>M1</p> <p>A1, A1</p> <p>(4)</p> <p>M1A1</p> <p>(2)</p> <p>B1</p> <p>M1A1</p> <p>M1M1</p> <p>A1</p> <p>A1cso</p> <p>(7)</p> <p><b>(13)</b></p>
<b>Notes</b>		
<p><b>(a)</b></p> <p><b>(b)</b></p> <p><b>(c)</b></p>	<p>B1 for suitable hypotheses</p> <p>M1 for correct use of Po(5). Award if one relevant probability is seen or a correct CR. Allow if a correct CR written as a Probability statement</p> <p>1<sup>st</sup> A1 for <math>X \leq 1</math> or <math>X &lt; 2</math> or <math>0 &lt; X &lt; 2</math> or <math>0 \leq X &lt; 2</math> or <math>0 &lt; X \leq 1</math> oe. Allow any letter</p> <p>2<sup>nd</sup> A1 for <math>X \geq 10</math> or <math>X &gt; 9</math> or <math>10 \leq x \leq 40</math> or <math>9 &lt; x \leq 40</math> oe. Allow any letter</p> <p>Ignore any <math>\cup</math> or <math>\cap</math> signs</p> <p>Do not allow CR written as probability statements</p> <p>M1 for adding their probabilities of 'their' critical regions if sum gives a probability less than 1 or award if a correct answer given</p> <p>A1 for awrt 0.0722 (o.e)</p> <p>B1 for suitable hypotheses</p> <p>1<sup>st</sup> M1 for normal approximation</p> <p>1<sup>st</sup> A1 for mean =25 and variance = 25 or sd = 5 may be seen in the standardiation formula or implied by a correct answer</p> <p>2<sup>nd</sup> M1 for attempting a continuity correction (Method 1: <math>19 \pm 0.5</math> / Method 2: <math>x \pm 0.5</math>)</p> <p>3<sup>rd</sup> M1 for standardising using their mean and their standard deviation and using either Method 1 [19.5, 19, 18.5 accept <math>\pm z</math>.] Method 2 [ <math>(x \pm 0.5)</math> and equal to a <math>\pm z</math> value]</p> <p>2<sup>nd</sup> A1 for awrt 0.136 or 35.3 or -1.1 &gt; -1.96</p> <p>3<sup>rd</sup> A1 for a correct contextualised conclusion. cao for a one tailed test, must come from correct working . Condone incorrect hypotheses.</p> <p><b>NB</b> if finding <math>P(X=19)</math> ie <math>P(X \leq 19.5) - P(X \leq 18.5)</math> they can get B1 M1 A1M1 M1 A0 A0</p>	

Question	Scheme	Marks
<p><b>6. (a)</b></p> <p><b>(b)</b></p> <p><b>(c)</b></p>	$\frac{d^2}{2} - \frac{d^4}{16} = \frac{1}{2}$ $[d^4 - 8d^2 + 8 = 0 \Rightarrow] 8 = (d^2 - 4)^2 \text{ or } d^2 = \frac{8 \pm \sqrt{64 - 32}}{2}$ $d^2 = 4 - \sqrt{8}$ $d = \sqrt{4 - \sqrt{8}} = 1.08239\dots$ <p style="text-align: right;">awrt 1.08</p> $f(d) = d - \frac{d^3}{4}$ $[f'(d) = 0 \Rightarrow] 1 - \frac{3d^2}{4} = 0$ $\left[ d^2 = \frac{4}{3} \text{ so } \right] d = 1.154\dots$ $f''(d) = -\frac{6d}{4} < 0 \text{ so max}$ $P(D < 1) = \left[ \frac{1}{2} - \frac{1}{16} \right] = \frac{7}{16}$ <p style="text-align: center;">Number of children = <math>80 \times \frac{7}{16} = 35</math></p>	<p>M1</p> <p>M1</p> <p>M1d</p> <p>A1 (4)</p> <p>M1</p> <p>M1A1</p> <p>A1</p> <p>B1 (5)</p> <p>B1</p> <p>M1, A1</p> <p>(3)</p> <p><b>(12)</b></p>
<b>Notes</b>		
<p><b>(a)</b></p> <p><b>(b)</b></p> <p><b>(c)</b></p>	<p>1<sup>st</sup> M1 for forming this equation based on <math>F(d) = 0.5</math> oe</p> <p>2<sup>nd</sup> M1 for attempting to solve (complete the square or use formula) –must be correct for their equation</p> <p>d3<sup>rd</sup> M1 for square rooting to get <math>d = \dots</math>. Do not award for <math>d = \text{awrt}1.17</math> Dependent on previous M being awarded.</p> <p>A1 for awrt 1.08 Must reject any negative answers</p> <p>1<sup>st</sup> M1 for attempting to find <math>f(d)</math>. Some correct differentiation. <math>x^n \rightarrow x^{n-1}</math></p> <p>2<sup>nd</sup> M1 for attempting <math>f'(d)</math> and setting it =0 Some correct differentiation <math>x^n</math> to <math>x^{n+1}</math></p> <p>1<sup>st</sup> A1 for a correct equation for <math>d</math></p> <p>2<sup>nd</sup> A1 for awrt 1.15 or 1.155 or <math>\sqrt{\frac{4}{3}}</math> or <math>\frac{2\sqrt{3}}{3}</math> or <math>\frac{2}{\sqrt{3}}</math> oe</p> <p>B1 for a method confirming that their value gives a max not a min</p> <p>M1 for <math>80 \times p, 0 &lt; p &lt; 1</math></p> <p>A1 for 35 only</p>	

Question	Scheme	Marks
7. (a)	$X \sim U[0, 9]$	B1 (1)
(b)	$[P(X > 6) =] \frac{1}{3}$ oe 0.333	allow awrt B1 (1)
(c)	$R = X(9 - X), = 9X - X^2$	M1, A1 (2)
(d)	$E(X) = 4.5$ $\text{Var}(X) = \frac{81}{12} = \frac{27}{4}$ or $E(X^2) = \int_0^9 \frac{x^2}{9} dx$ $E(X^2) = \text{Var}(X) + [E(X)]^2$ or $= \left[ \frac{x^3}{27} \right]_0^9$ $E(X^2) = 27$ So $E(R) = 9 \times 4.5 - 27 = 13.5$	B1 B1 M1 A1 dM1A1 (6)
	<u>Alternative method</u> $\int_0^9 \frac{(9x - x^2)}{9} dx = \left[ \frac{9x^2}{18} - \frac{x^3}{27} \right]_0^9$ $= \frac{81}{2} - \frac{81}{3}$ $= 13.5$	B1 B1 M1A1 dM1 A1
(e)	$R > 2X^2$ or $9X - X^2 > 2X^2$ $9X > 3X^2$ So $P(X < 3)$ $= \frac{1}{3}$	M1 A1 M1 A1 (4) (14)

Notes	
(a)	<p>B1 for <math>X \sim U[0, 9]</math> or “continuous uniform”/”rectangular” distribution with correct range</p> <p>Or allow the pdf <math>f(x) = \begin{cases} \frac{1}{9} &amp; 0 \leq x \leq 9 \\ 0 &amp; \text{otherwise} \end{cases}</math></p>
(c)	<p>M1 for <math>X(9 - X)</math> or <math>9X - X^2</math> may be implied by a correct answer</p> <p>A1 for <math>9X - X^2</math> or <math>a = -1</math> and <math>b = 9</math></p>
(d)	<p>1<sup>st</sup> B1 for 4.5 or may be implied</p> <p>2<sup>nd</sup> B1 for <math>\frac{81}{12}</math> or <math>\frac{27}{4}</math> or <math>\int_0^9 \frac{x^2}{9}</math> ignore limits</p> <p>1<sup>st</sup> M1 for full method for <math>E(X^2)</math> using their <math>\text{Var}(X)</math> and <math>E(X)</math> or attempt to integrate <math>x^n \rightarrow x^{n+1}</math> leading to a value for <math>E(X^2)</math>. Need to be using <math>\int_0^9 \frac{x^2}{9}</math> ignore limits.</p> <p>1<sup>st</sup> A1 for <math>E(X^2) = 27</math>, may be implied.</p> <p>d2<sup>nd</sup> M1 for using <math>9E(X) - E(X^2)</math>. With their <math>E(X)</math> and <math>E(X^2)</math>. This may be implied by a correct answer. Dep on first M</p> <p>Alternative</p> <p>B1 <math>\int_0^9 \frac{(9x - x^2)}{9} dx</math> ignore limits, ft their (c) which must be of the form <math>aX^2 + b</math></p> <p>B1 <math>\int_0^9 \frac{(9x - x^2)}{9} dx</math> with correct limits, ft their (c)</p> <p>M1 attempt to integrate at least one <math>x^n \rightarrow x^{n+1}</math>. Need to be using their <math>\int_0^9 \frac{(9x - x^2)}{9} dx</math></p> <p>condone limits missing</p> <p>A1 Correct Integration</p> <p>dM1 subst in limits, need to see 9 substituted. Condone missing 0</p>
(e)	<p>Allow <math>\leq</math> instead of <math>&lt;</math> and <math>\geq</math> instead of <math>&gt;</math> in this part</p> <p>1<sup>st</sup> M1 for forming a suitable inequality in <math>R</math> and <math>X</math> or just <math>X</math>. May be implied by a correct probability in <math>X</math>.</p> <p>1<sup>st</sup> A1 for simplifying to <math>9X &gt; 3X^2</math> or <math>3 &gt; X</math>. May be implied by a correct probability in <math>X</math></p> <p>2<sup>nd</sup> M1 for forming a correct probability in <math>X</math></p> <p>2<sup>nd</sup> A1 for <math>\frac{1}{3}</math> or exact equivalent</p>

