edexcel

Mark Scheme (Results)

Summer 2016

Pearson Edexcel GCE Statistics S2

(6684/01)

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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.
- 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
   - $\lfloor$ 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 2016
6684 Statistics S2
Mark Scheme

Question Number	Scheme		Marks
Note : if a correct answer is given with no incorrect working award full marks unless the markscheme says otherwise.			
1(a)	Mean = 1.41	B1: Cao Allow 141/100	B1
	Variance = $\frac{343}{100} - 1.41^2$	M1: using $\frac{\sum fx^2}{100} - (\text{their mean})^2$ or $\frac{100}{99}\left(\frac{\sum fx^2}{100} - (\text{their mean})^2\right)$ oe NB Allow the square root of this for the M mark. If no working shown for $\sum fx^2$ then you must see 343, 3.43 or a correct answer	M1
	= 1.4419 ($s^2 = 1.456$)	A1: awrt 1.44 or 1.46 for s^2	A1
			(3)
(b)	The mean is close to the variance	B1: Cao - allow alternative wording Allow mean equals variance	B1 (1)
(c) (i)	X~Po(1.5) $P(X = 2) = \frac{e^{-1.5}1.5^2}{2!}$	M1: writing or using $\frac{e^{-\lambda}\lambda^2}{2!}$ or $P(X \le 2) - P(X \le 1)$	M1
	= 0.2510	A1: awrt 0.251	A1
(ii)	$P(X \ge 1) = 1 - P(X = 0)$ $= 1 - e^{-1.5}$ 0r 1 – 0.2231	M1: writing or using $1 - P(X = 0)$ oe	M1
	= 0.77686….	A1: awrt 0.777	A1 (4)
(d)	Y~Po(7.5)	B1: Writing Po(7.5)	B1
	$P(Y \ge 11) = 1 - P(Y \le 10)$	M1: writing $P(Y \ge 11)$ or $1 - P(Y \le 10)$ oe	M1
	= 1 – 0.8622 = 0.1378 *	A1: Seeing 1 – 0.8622 leading to 0.1378 cso (both B1 and M1awarded)	A1cso (3)
(e)	A~ B(12, 0.1378)	M1: using $(p)^n(1-p)^{12-n}$ where p = 0.1378 or 0.138 condone missing nCr	M1
	$P(A = 3) = \binom{12}{3}(0.1378)^3(0.8622)^9$	M1: $\binom{12}{3}(p)^3(1-p)^9$, with $0 < p < 1$ Allow 220 or 12 C 3 instead of $\binom{12}{3}$	M1
	= 0.1516	A1: awrt 0.152	A1 (3)
			Total 14

Question Number	Scheme		Marks
2(a)	$0.05n = 3$	M1: using $0.05n$	M1
	$n = 60$	A1: cao NB: for 60 with no incorrect working award M1A1	A1 (2)
(b)	$R \sim B(20, 0.05)$	B1: using or writing B(20, 0.05) in (i) or (ii)	B1
(i)	$P(R = 4) = {}^{20}C_4 (0.05)^4 (0.95)^{16}$ **OR** $P(R = 4) = P(R \le 4) - P(R \le 3)$ $= 0.9974 - 0.9841$	M1 writing or using $P(R \le 4) - P(R \le 3)$ or using ${}^{20}C_4 (p)^4 (1-p)^{16}$	M1
	$= 0.0133$	A1: awrt 0.0133	A1
(ii)	$P(R \ge 4) = 1 - P(R \le 3)$ $= 1 - 0.9841$	M1: writing or using $1 - P(R \le 3)$	M1
	$= 0.0159$	A1: awrt 0.0159	A1 (5)
(c)	$H_0: p = 0.05$ $H_1: p > 0.05$	B1: Both hypotheses correct and labelled H_0 and H_1, must use p or π Do not allow $p(x)$	B1
	$P(R \ge 4) = 1 - P(R \le 3)$	M1: Writing or using B(50,0.05) AND writing or using $1 - P(R \le 3)$ **or** $P(R \le 3) = 0.7604$ on its own **or** one of the following 4 statements leading to a CR. $P(R \ge 7) = 0.0118$ $P(R \le 6) = 0.9882$ $P(R \ge 8) = 0.0032$ $P(R \le 7) = 0.9968$ May be implied by correct CR. Allow any letter	M1
	$= 0.2396$ CR $R \ge 8$	A1: awrt 0.240 or 0.24 or $R \ge 8$ oe Or 0.7604	A1
	Insufficient evidence to reject H_0, Not Significant. Accept H_0. 4 does not lie in the Critical region.	M1: dependent on the previous M being awarded. A correct statement – do not allow contradictory non contextual statements. Follow through their Probability/CR and H_1. If no H_1 seen then M0. **Ignore their comparison in all cases** Then mentally compare **their probability** as follows: For prob < 0.5 statement must be correct compared to 0.01 for 1 tail test and 0.005 for 2 tailed test. For prob > 0.5 statement must be correct compared to 0.99 for 1 tail test and 0.995 for 2 tailed test. **NB**:If there is no non-contextual statement given you may award the M1for a correct contextual statement	M1d
	No evidence to support **Patrick's** claim. Or no evidence that people in *Reddman* have a probability greater than 5% of having **red hair**	A1: **cso** fully correct solution and correct contextual statement containing the word **Patrick** if writing about the claim Or **red hair** if full context	A1**cso** (5)
			Total 12

Question Number	Scheme		Marks
3(a)	$f(r)=\begin{cases}\frac{1}{4} & 5\le r\le 9\\ 0 & \text{otherwise}\end{cases}$	B1: Allow $r<5$ and $r>9$ instead of 0 otherwise Allow < instead of ≤ signs. Any letter may be used - condone mixed letters Must have f(r) – condone F(r)	B1 (1)
(b)	$P(7<R<10)=2\times\frac{1}{4}$ $=\frac{1}{2}$	B1: oe	B1 (1)
(c)	$[E(A)=E(\pi R^2)]$ $E(R^2)=\text{Var}(R)+[E(R)]^2$ or $\int_5^9\frac{r^2}{4}dr$	M1: Using correct formula for $E(R^2)$. This may be in any order or written in words	M1
	$E(R)=7,\quad \text{Var}(R)=\frac{4}{3}$ **or** $\left[\frac{r^3}{12}\right]_5^9$	B1: $\text{Var}(R)=\frac{4}{3}$ or awrt 1.33 **and** $E(R)=7$ **or** $\left[\frac{r^3}{12}\right]_5^9$. These may be implied by a correct answer	B1
	$=50\frac{1}{3}$	A1: Allow awrt 50.3	A1
	$E(A)=50\frac{1}{3}\pi$ oe	A1: Allow **exact** multiple of π eg $50.\dot{3}\pi$ or awrt 158 Do Not allow 50.3π	A1 (4)
	NB If both $E(R)^2$ and $[E(R)]^2$ are both worked out and neither is selected they lose the final A marks. The best they can get is M1 B1 A1A0		
			Total 6

Question Number		Scheme	Marks
Mark (a) and (b) together – allow a missing *k* throughout			
4(a)	$f(x) = ak + 2bkx - 3kx^2$	M1: Attempting to differentiate F(x) at least one $x^n \to x^{n-1}$	M1
	$\left[\dfrac{df(x)}{dx} =\right] 2kb - 6kx$	M1d: Attempting to differentiate f(x) at least one $x^n \to x^{n-1}$. Dependent on previous M mark being awarded. A1: Condone missing $\dfrac{df(x)}{dx}$	M1dA1
	$2kb - 6kx = 0$ $k(2b - 6x) = 0$ $2b - 6x = 0$	M1d: Putting 2nd differential = 0 Dependent on previous Method mark being awarded	M1d
	$2b - 6\times\dfrac{8}{3} = 0$	M1d: Subst $x = \dfrac{8}{3}$. Allow with k in. Dependent on previous Method mark being awarded	M1d
	$b = 8$*	A1: Answer given so must have been awarded all previous marks with no errors	A1 cso
	Alternative method – completing the square		(6)
	$-3k\left(x^2 - \dfrac{2bx}{3} - \dfrac{a}{3}\right)$	M1: factorising by taking -3k out	M1
	$-3k\left(\left(x - \dfrac{b}{3}\right)^2 - \left(\dfrac{b}{3}\right)^2 - \dfrac{a}{3}\right)$ or quoting $\dfrac{-b}{2a}$	M1: Attempting to complete the square dependent on previous M mark being awarded. $\left(x - \dfrac{b}{3}\right)^2 \pm c$	M1d
	$-3k\left(x - \dfrac{b}{3}\right)^2 + \dfrac{b^2k}{3} + ak$	A1: Correct completed square form	A1
	Max at $x = \dfrac{b}{3}$	M1d: Selecting their b/3 Dependent on previous Method mark being awarded	M1d
	$\dfrac{b}{3} = \dfrac{8}{3}$	M1: Putting their $\dfrac{b}{3} = \dfrac{8}{3}$. Dependent on previous Method mark being awarded	M1d
	$b = 8$*	A1: Answer given all steps must have shown all the required steps	A1 cso
(b)	F(2) = 0 eg $k(2a + 32 - 8) = 0$ Or $k(2a + 4b - 8) = 0$ oe $a = -12$	M1: Attempting to form an equation using F(2) = 0, or F(3) = 1 or F(3) – F(2) =1. Need to subst in the x value and equate A1: –12 - may be implied by k = 1/9. Do not award if the M1 is not given	M1 A1
	$F(3) = 1$ eg $k(-36 + 72 - 27) = 1$ $k(-36 + 9b - 27) = 1$ oe $k = \dfrac{1}{9}$	M1: Forming an equation using two of F(2) = 0 or F(3) = 1 or F(3) – F(2) =1 A1: Allow equivalent fractions or awrt 0.111	M1 A1
NB If you see k =1/9 award full marks. You may award marks in part (b) for equations seen in (a)			(4)
SC if –b/2a quoted and not proved do not award the A marks. Max mark is M1M1A0M1M1A0			**Total 10**

Question Number	Scheme		Marks
5.	N($0.2n$, $0.16n$)	B1: Mean = $0.2n$ and Var = $0.16n$ oe this may be awarded if they appear in the standardisation as $0.2n$ and either $0.16n$ or $\sqrt{0.16n}$	B1
	$P\left(Z > \frac{55.5-0.2n}{\sqrt{0.16n}}\right) = 0.0401$	M1: Using a continuity correction either 55.5 or 54.5	M1
	$\frac{55.5-0.2n}{\sqrt{0.16n}} = 1.75$	B1: Using a z = awrt $\pm$ 1.75 M1: Standardising using either 55.5, 54.5 or 55 and equal to a z value. Follow through their mean and variance. If they have not given the mean and Var earlier then they must be correct A1: A correct equation. May be awarded for $\frac{55.5-0.2n}{\sqrt{0.16n}} = 1.75$ Condone use of an inequality sign rather than an equals sign	B1M1A1
	$0.2n + 0.7\sqrt{n} - 55.5 = 0$	M1**d**: This is dependent on the previous method mark being awarded. Using either the quadratic formula or completing the square or factorising or any correct method to solve **their 3 term** equation. If they write the formula down then allow a slip. If no formula written down then it must be correct for their equation. May be implied by correct answer or $\sqrt{n} = 15$ or 342.25 **NB** you may award this mark if they use 54.5 for awrt 14.9, -18.4, 221 or 337 55 for awrt -18.4, 14.9,223 or -117 If the answer is not one of these then the method for solving their 3 term equation must be seen.	M1**d**
	$\sqrt{n} = 15$	A1: Allow 15 or -18.5 do not need to see n or $\sqrt{n}$. Condone n = 15 or n = -18.5	A1
	$n = 225$	A1 : cao 225 do not need to see n or $\sqrt{n}$	A1 (8)
	Alternative method for last 3 marks $(0.2n - 55.5)^2 = (-0.7\sqrt{n})^2$ $0.04n^2 - 22.69n + 3080.25 = 0$ n = 225 or 1369/4 n = 225	M1 solving 3 term quadratic in n as above A1 either 225 or 1369/4 or 342.25 A1must select 225	**Total 8**

<table>
<tr><th>Question Number</th><th>Scheme</th><th></th><th>Marks</th></tr>
<tr><td>6.(a)</td><td>44, 46, 48, 66, 68, 88

NB 64 is the same as 46, 84 is the same as 48, 86 is the same as 68</td><td>B1: At least 4 different pairs (ignore incorrect extras)
B1: 6 different pairs with no incorrect extras</td><td>B1B1

(2)</td></tr>
<tr><td>(b)</td><td>
<table>
<tr><td>$\bar{x}$</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr>
<tr><td></td><td></td><td>$\frac{1}{2}\times\frac{3}{10}\times 2$</td><td>$\frac{3}{10}\times\frac{3}{10}+\frac{1}{2}\times\frac{1}{5}\times 2$</td><td>$\frac{3}{10}\times\frac{1}{5}\times 2$</td><td></td></tr>
<tr><td>$P(\bar{X}=\bar{x})$</td><td>$\frac{1}{4}$</td><td>$\frac{3}{10}$</td><td>$\frac{29}{100}$</td><td>$\frac{3}{25}$</td><td>$\frac{1}{25}$</td></tr>
</table>
</td><td></td><td>B1
B1
M1
M1A1</td></tr>
<tr><td></td><td>B1: 4,5,6,7,8 only no extras or omissions</td><td></td><td></td></tr>
<tr><td></td><td>B1: Writing or using $P(X=4)=\frac{1}{2}$, $P(X=6)=\frac{3}{10}$ and $P(X=8)=\frac{1}{5}$ May be seen in(a)</td><td></td><td></td></tr>
<tr><td></td><td>M1: A correct method for one of P(5), P(6) or P(7) may be implied by correct answer
M1: A correct method for two of P(5), P(6) or P(7) may be implied by correct answer</td><td></td><td></td></tr>
<tr><td></td><td>A1: fully correct table/list -need 4,5,6,7, 8 and their associated probabilities</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>(5)</td></tr>
<tr><td>(c)</td><td>$1-\left(\frac{24}{25}\right)^n>0.9$ or $\left(\frac{24}{25}\right)^n<0.1$ oe</td><td>M1: $1-\left(\frac{24}{25}\right)^n>0.9$ or $\left(\frac{24}{25}\right)^n<0.1$ oe seen or used
may use = or ≤ instead of <
= or ≥ instead of >
Do Not award $\left(\frac{24}{25}\right)^n>0.1$ oe</td><td>M1</td></tr>
<tr><td></td><td>$n > 56.4$</td><td>A1: Ignore any $n>$, $n<$, $n=$ etc. Award if you see awrt 56.4 may be implied by $n = 57$</td><td>A1</td></tr>
<tr><td></td><td>$n = 57$</td><td>A1: cao $n = 57$ or 57 on its own. Do not allow $n > 57$ or $n < 57$. Do not award if alternative values are given. You must check there is no incorrect working</td><td>A1</td></tr>
<tr><td></td><td>Alternative – trial and error
<table>
<tr><td>50</td><td>0.87</td><td>0.13</td></tr>
<tr><td>51</td><td>0.865</td><td>0.125</td></tr>
<tr><td>52</td><td>0.88</td><td>0.12</td></tr>
<tr><td>53</td><td>0.885</td><td>0.115</td></tr>
<tr><td>54</td><td>0.89</td><td>0.11</td></tr>
<tr><td>55</td><td>0.894</td><td>0.106</td></tr>
<tr><td>56</td><td>0.898</td><td>0.102</td></tr>
<tr><td>57</td><td>0.902</td><td>0.098</td></tr>
<tr><td>58</td><td>0.906</td><td>0.094</td></tr>
<tr><td>59</td><td>0.91</td><td>0.09</td></tr>
<tr><td>60</td><td>0.94</td><td>0.086</td></tr>
</table>
Allow awrt</td><td>M1 at least 2 trials for $50 \le n \le 60$ shown with correct probabilities

A1 trial for $n = 56$ and 57 shown with correct probabilities</td><td>M1

A 1</td></tr>
<tr><td></td><td>$n = 57$</td><td>A1: cao $n = 57$ or 57 on its own. Do not allow $n > 57$ or $n < 57$. Do not award if alternative values are given</td><td>A1
(3)</td></tr>
<tr><td></td><td></td><td></td><td>Total 10</td></tr>
</table>

Question Number	Scheme		Marks
7(a)	$\int_0^2 \frac{9x^2}{10} - \frac{3x^3}{10}\,dx = \left[\frac{3x^3}{10} - \frac{3x^4}{40}\right]_0^2$	M1: using $\int xf(x)$ and attempting to integrate. At least one $x^n \to x^{n+1}$. Ignore limits A1: Correct integration - Ignore limits	M1A1
	$= \left(\frac{3\times 2^3}{10} - \frac{3\times 2^4}{40}\right)$	M1d: substituting correct limits -dependent on previous Method mark being awarded	M1d
	= 1.2	A1: 1.2 oe. Allow 1.20	A1 (4)
(b)	$E(X^2) = \int_0^2 \frac{9x^3}{10} - \frac{3x^4}{10}\,dx$ $= \left[\frac{9x^4}{40} - \frac{3x^5}{50}\right]_0^2$	M1 using $\int x^2 f(x)$ and attempting to integrate. At least one $x^n \to x^{n+1}$. Ignore limits	M1
	$= \frac{42}{25}$ =1.68	A1: Allow equivalent fractions. May be implied by a correct answer. Condone Var(X) = 1.68	A1
	Var (X) = 1.68 – 1.2^2	M1d: use of $E(X^2) - E(X)^2$	M1d
	= 0.24	A1: cao allow 0.240 or 6/25oe	A1 (4)
(c)	[P(X > 1.5) =] $\int_{1.5}^2 \frac{9x}{10} - \frac{3x^2}{10}\,dx$ **or** $1 - \int_0^{1.5} \frac{9x}{10} - \frac{3x^2}{10}\,dx$	M1: writing or using $\int_{1.5}^2 \frac{9x}{10} - \frac{3x^2}{10}\,dx$ **or** $1 - \int_0^{1.5} \frac{9x}{10} - \frac{3x^2}{10}\,dx$ Must have correct limits or using 1 – F(1.5) for this distribution	M1
	$= \left[\frac{9x^2}{20} - \frac{3x^3}{30}\right]_{1.5}^2$ or $1 - \left[\frac{9x^2}{20} - \frac{3x^3}{30}\right]_0^{1.5}$	A1 Correct Integration. Condone missing 1-	A1
	$= \frac{13}{40} = 0.325$	A1cso: 0.325 or 13/40 oe	A1cso
NB	**Watch out for using 1 – f(1.5) or** $1 - \frac{9(1.5) - 3(1.5)^2}{10}$ **. This gets M0A0A0**		(3)
(d)	$(0.325)\times 25 + (1 - 0.325)\times 50$ = £41.875	M1 $(their(c))\times 25 + (1 - their(c))\times 50$ Allow use of their part (c) or 0.325 ie they may restart. Allow 50 – (part(c))×25 A1: awrt 41.9	M1A1 (2)
(e)	£50×0.8 or £40 or 0.4 or awrt 0.038 or awrt 0.163 Peter should not remove the **staples** as the expected amount earned per bin will be less.	M1:Allow $(50\times 0.8)n$ or £40n $(n \neq 0)$ NB Allow 20% off (of) 50 =£40 A1ft: Correct statement containing the word **staples** and one of the 4 comparisons (ft on (c) or (d)) or the difference in these values must be seen. £40n < part(d)×n or 0.4 < their part (c) or 0.6 < 1-their part(c) or awrt 0.838 > 0.8 or 0.162 < 0.2	M1 A1ft (2)
			Total 15

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